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Frank Harvey

GUNSHOT INJURIES

'Il n'est peut-être pas dans le vaste domaine de la Chirurgie un sujet aussi complexe, qui embrasse un aussi grand nombre de questions pratiques, dont le diagnostic et le traitement exigent de l'homme de l'art des connaissances plus étendues, plus de rectitude dans le jugement, plus d'habileté dans l'exécution, que les blessures par les armes de guerre en général, et en particulier par les armes à feu.'

Leçons Orales de Clinique Chirurgicale, faites à l'Hôtel-Dieu de Paris. Par M. le Baron DUPUYTREN.
Paris : 1832. Tome ii. p. 417.

'Gunshot wounds are now become almost a distinct branch of Surgery.'

JOHN HUNTER'S Works : *Of Gunshot Wounds*, Ch. i. par. 1.

GUNSHOT INJURIES:

THEIR HISTORY, CHARACTERISTIC FEATURES, COMPLICATIONS, AND GENERAL TREATMENT;

WITH STATISTICS CONCERNING THEM AS THEY HAVE BEEN MET WITH IN WARFARE.

BY

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INTRODUCTION[1]

The subject of Gunshot Injuries and their treatment has acquired a large amount of interest of late years. Neither time, nor money, nor mechanical skill have been spared in promoting efforts to produce guns and rifles of more and more destructive qualities. Nations the most prominent in civilisation have alike vied with each other in struggling to obtain armaments of such numerical superiority and overpowering weight as shall enable them the more surely to disable all antagonists to whom they may happen to become opposed. From time to time the improved fire-arms resulting from these continued efforts to secure military ascendancy, have been practically turned to account in national conflicts, and opportunities have been unhappily afforded of observing the injuries inflicted by them in vast and overwhelming numbers.

One result of this experience is to show that gunshot injuries have thrust all other kinds of injuries into the background in modern warfare. Wounds by cutting and stabbing weapons are so few in proportion to them, that they no longer occupy the place of interest among the injuries of war which they held at comparatively recent periods. The number of field guns has been largely increased in all armies. Portable fire-arms are now almost universally distributed among troops. Not only infantry soldiers, whose special weapon the musket or rifle has always been, but cavalry soldiers, engineers, gunners, and men of the Army Service Corps, all carry fire-arms of some description. Thus, when war occurs, the wounds and injuries resulting from battle which the military surgeon may expect to have to treat are almost exclusively those from gun and rifle projectiles. Nor are such injuries limited to the notice of military surgeons. Irrespective of the employment of guns for sporting purposes, the practice with rifles and

[1] The former edition, from which this Introduction has been taken, was published in 1877.

other forms of fire-arms has become so general that gunshot injuries are now by no means uncommon accidents in civil life. It is for these reasons, and because their special characters are so intrinsically different from those of incised wounds, that I have devoted this work to a separate study of them.

Some persons still cling to the belief that the time for appealing to the arbitrament of war has gone by, that difficulties among the nations which are most advanced in civilisation will in future be solved by laying the questions to which they owe their origin before selected judges, whose decision upon them will be submitted to by the disputants as final. The settlement of certain differences of views between Great Britain and the United States by this mode of procedure is quoted in favour of the opinion. Such a consummation as a general agreement to follow this example is heartily to be desired; and it would be gratifying indeed if the practical men of the world could only see good cause for believing in the likelihood of its realisation. But, alas! that it is not so, and cannot be so, unless in rare, exceptional instances, is but too evident. All will admit that national conflicts are not rushed into so ignorantly and heedlessly, nor at the dictation of so limited a number of individuals, in our day as they appear to have been in former times; but it is difficult to find any firm resting-place for the belief that the time for their discontinuance is near at hand. Knowledge is more diffused; the terrible evils of war, and the extent to which they spread, are more widely known and more thoroughly appreciated; life is estimated at a higher value; the desire to lessen suffering, and to improve the social condition of the humbler classes, is more generally predominant; there is more to be lost by war, owing to the increase of personal property and the growth of closer commercial relations among nations; and all these circumstances act, up to a certain point, as hindrances to a rupture of peaceful relations between empires and states. But they are impediments that are quickly overcome under the influence of passion and excitement. When Power, in full reliance on its strength, puts forth pretexts for aggression; when there are believed wrongs to be avenged, or rights to be defended; when arguments addressed to reason and prudence, instead of producing a conciliatory feeling, only serve to provoke additional irritation in the multitude; when the counsel of friends, and even

the decisions of arbitrators, are rejected by the disputants—force, in the shape of war, is still made, as it ever has been, the court of final appeal. In social life an irresistible force, which is nothing less than the power of the whole community expressed through its appointed laws and agents, restrains the conduct of individuals under like circumstances; but what force is there so strong as to be able to control the ambitious aspirations and violent actions of nations? All who are of sufficient age must remember how widely, some five-and-twenty years ago, the conviction prevailed in England that nations would no more appeal to arms for the settlement of their disputes, but would submit them to diplomatic management. This delusion vanished before the stern realities of the Crimean struggle. And how many wars since have still further shown the visionary character of that faith! Not to dwell on our own conflicts in the East—the war of the Indian Mutiny, the China Wars of 1857 and of 1860, with the Abyssinian and Ashanti Expeditions—there have been the Italian War of 1859, the great Civil War on the American continent, the Mexican War, the German War against Denmark of 1864, that against Austria in 1866, the War of 1870 between Germany and France, the Turco-Servian War, and now (1877) the war, waged with such cruel destruction on both sides, of the Russian invasion of Turkey, the limits and end of which it is as yet impossible to foresee. Truly, our century has no more exhibited signs of war having ceased than has the history of man shown that nations ever have been content to live for a long series of years at peace with one another. The true philanthropist, knowing from the nature of man what consequences, now as heretofore, may be evoked when hostile feelings are aroused, will try, even when armed and ready for strife in defence of right, by the exercise of justice and benevolent consideration for others, to prevent the occurrences which call passions into existence, and so to avert an appeal to violence; but he will neither delude himself, nor try to delude others, with a belief that an era of universal harmony has been entered upon, and that wars will henceforth be no more. Preparations in all the combatant requirements for war have been and are, in fact, in constant progress; and under such circumstances the Army Medical Staff, if wise, will also appreciate the need of providing for the future, and making suitable prepara-

tions for the special exigencies which it will have to meet should war occur.

> 'Metuensque futuri,
> In pace, ut sapiens, aptârit idonea bello.'

Few men have an acquaintance with the terrible individual sufferings which directly result from battle so thrust upon them as military surgeons. The consequences of war are brought to their notice in an almost infinite variety of forms. If war were truly, as regards the combatants, what poets are too apt to paint it, a matter of glory on one hand, or of speedy death on the other, it would not, after all, be nearly so terrible as it really is.

> 'Concurritur : horæ
> Momento cita mors venit, aut victoria læta.'

But, unhappily, army surgeons know too much of other alternatives; not merely the wounds and tortures of the field of action, but also of what follows them—prolonged suffering, sometimes destined to last as long as life itself, and sad mutilations, rendering existence a struggle, or depriving it of all, or nearly all, enjoyment. Army surgeons know so much of these results of gunshot injuries; they have them in such large numbers, and for such long periods, before them—that strange, indeed, must be the feelings of those who are not influenced by an earnest desire to be acquainted with every professional resource that can be turned to account for mitigating such terrible evils.

The extract from the writings of the experienced and distinguished surgeon Dupuytren, which I have placed at the beginning of this volume, expresses very forcibly the difficulties with which the subject of gunshot injuries is surrounded. It is only by previous careful study, by scientific acquaintance not only with the injuries themselves, but also with the instruments and forces by which they are produced and on which their special features depend, and by a knowledge of the experience which has been gained by successive practical observers, that the nature and characters of gunshot injuries can be properly understood, or their appropriate treatment determined. It is essentially necessary for surgeons engaged in military practice to be provided beforehand with this special knowledge. The injuries occur so numerously

on fields of battle, and in such rapid sequence—to a vast extent, indeed, it may be said, simultaneously—that, to afford efficient aid, the surgeon's decision and action must be ready on the moment. In civil practice there is usually ample time at disposal for studied consideration of each particular injury, as well as for its leisurely treatment; in field practice there is rarely time for deliberation or discussion. Lives depend on assistance being given without hesitation and on the instant. But to be of real service, not only must the urgent demands for surgical aid be met at once, they must also be responded to suitably, according to the special exigencies of each particular case, and that, too, often with very limited material resources at hand. Self-reliance gained from knowledge, the wit to turn everything at hand to account, and previously acquired manual dexterity, will alone enable the army surgeon to fulfil his duties on such occasions with benefit to others and with satisfaction to himself.

Military surgeons can never estimate beforehand the number of injuries of the severest character which may demand their attention when warfare is in progress. The statistics which are furnished in a special section of this work show the number of wounds which have been inflicted on certain occasions of battle and in certain wars; but, independently of the fact, elsewhere shown, that these casualties have been very unevenly distributed in regard to special parts of the armies concerned, it is to be remembered that the military surgeons on the conquering side are not only called upon to minister to the wants of their own wounded, but usually have to treat those of the enemy also who are left in the hands of the victors. In the savage condition of man the wounded who fell into the hands of the conquerors were usually treated as spoils of war. No efforts were made to relieve their sufferings or their misfortunes; if badly wounded, they were left to die or were killed outright; if they chanced to survive, they were used as slaves, or subjected to other indignities. As man has become more civilised he has allowed better feelings to dominate him, and the wounded enemy whom the fate of war has rendered a prisoner has been acknowledged to have a title to consideration. His claim to surgical care and attention has gradually been conceded. These principles have grown in strength as civilisation has further advanced, until in recent years the enemy, when wounded

and disabled, has almost ceased to be regarded as a foe, and is held to have a right to the same care and attention as the wounded of the conquering forces to whose power he has succumbed. In modern preparations for war, indeed, when rightly conducted, provision of additional surgical and medical materials is usually made to meet such extraneous demands on the resources of the hospital establishments. By the terms of the Geneva Convention —and it is a pleasure to me to remember that I participated in framing them—surgeons of the defeated army may be left to assist in taking care of its wounded without being made prisoners of war, and the necessary ambulance equipment and materials without being captured as prize of war. This treaty has still further increased the means of responding to the demands of humanity on such occasions.

There is another subject, of such serious practical importance when considering gunshot injuries and their general treatment in the field, that I may be pardoned for referring to it here in addition to having dwelt upon it at length in the body of the work. It is that of Field Hospital Organisation, and of the administrative arrangements for the care and disposal of the large numbers of wounded which now commonly result from great battles. It can hardly be said that this subject has ever, until recently, occupied the important position in military studies in this country which it has deserved to hold. Indeed, until the appointment, subsequently to the Crimean War, of the Royal Commission to inquire into the Organisation of the Medical Department of the Army, of which the late Lord Herbert was chairman, it had never received the serious attention of persons in authority.

The operation of collecting, removing, and attending to the first wants of the mass of wounded resulting from a great battle is a vast and serious concern. The manner in which this service is performed is not merely important in respect to preventing aggravation of existing suffering, but the question of life itself, in numerous instances, is involved in the proceeding, and, in many others, the whole future state of the wounded, whether it shall be one of continued pain and of comparative uselessness, or the reverse of these conditions, will be influenced by it. It is a duty which not only requires the necessary amount of transport power, but also thorough organisation, special training, immense energy,

and undivided attention, for it to be conducted in an adequate manner. It cannot be treated as secondary or subordinate to other matters of duty, if it is to be executed with anything approaching to that perfection of system under which the fighting services of the army are habitually conducted. Yet it was usually dealt with as altogether inferior in estimation to other military duties. It was intrusted to a department of the army, the Quartermaster-General's, which had no training for it, and which was responsible for a large amount of other distinct duties of great military importance. It always proved impossible for this department to give the amount of attention to this service which, from its nature, it required in time of war.

But the removal of the wounded, and a general attention to their first wants, is but a small part of the work which their proper care and treatment demand when armies are on active service. The duties, administrative and executive, when masses of wounded have to be provided for—when not unfrequently, too, the hospital service is charged with the care of a large number of sick also—are necessarily very onerous and of a very special character. They bear scarcely any resemblance to the duties devolving on medical practitioners who follow their avocations in settled communities, either in the modes of conducting them, or in the material appliances employed in their execution. It cannot be said that these functions have ever been discharged by the Medical Departments of armies in the manner it might well be desired that they should have been in the interests of the wounded; but it can be truly said that, as a rule, they have been performed by them far better than it might have been anticipated the means at their command, whether of preparation or of execution, would have enabled them to do.

I believe it to be unnecessary to describe the general plan of this treatise; it is sufficiently shown in the tabular arrangement of its contents. The history of the successive changes which have taken place in the characters of gunshot injuries since they were first presented in warfare will not be found in any special chapters on the subject. It has been sufficiently given, however, in the chapters on the alterations in fire-arms and projectiles to which the variations in their characters have been chiefly attributable. It is believed that this arrangement will have the advantage of

being less formal, and of leading to a clearer understanding of their principal features as they are exhibited at the present day.

It will also be noticed that the authorities for some of the statements in the text, together with occasional observations upon them, have been removed to the end of the work, instead of being placed with the text itself, as is more customary. The majority of readers will probably prefer not to be interrupted by references on the same page as the narrative, while those who have a desire for the subsidiary information can readily obtain it by reference to the Appendix. In no case can the information placed in the Appendix be said to be essential to the descriptive remarks in the text; but in most instances it is hoped that it will be found of interest to those who may choose to apply to it, either as confirmatory or illustrative of the matters treated upon in the several sections.

T. L.

PREFACE TO THE SECOND EDITION

The nature and scope of this work are so fully shown in the preceding extracts from the Preface to the First Edition, that but few additional prefatory remarks appear to be now needed. About seventeen years have passed since that edition was published, and during this period successive changes of a remarkable character and of great importance have been carried out in the fire-arms and projectiles of all the leading armies of the world. The probable effects of the altered weapons on the wounds and injuries which they are calculated to produce, should war unhappily occur, require to be carefully considered by every military surgeon. At the same time that alterations in the weapons of war have been taking place, material changes have been in progress in military hospital organisation, in the methods of wound treatment, and in the position and functions of the medical officers to whom, in case of war arising, the treatment of the soldiers wounded in the field would be intrusted. It is the aim of the present work not only to give an account of the various changes which have just been alluded to, but also to bring the information which was contained in the former edition on many other topics up to present date. Neither time nor trouble has been spared in the endeavour to accomplish these objects, and the work is now put forth in the hope that it may prove to be of service to all surgeons who may have to deal with injuries resulting from fire-arms, but especially to the rising generation of army surgeons, on whom the wounded, in time of need, must principally depend for the alleviation of their sufferings at the earlier periods of their injuries, and, in numerous instances, for the ultimate safety of their limbs and lives.

T. L.

WOOLSTON, HANTS, 1895.

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GUNSHOT INJURIES, AND THE MEANS BY WHICH THEY ARE PRODUCED

CHAPTER I

DEFINITION, NOMENCLATURE, AND PRODUCTION OF GUNSHOT INJURIES

Definition.—Gunshot Injuries are the injuries caused by missiles which have been propelled by the agency of a sudden violent expansive force. This force is usually obtained for military purposes from the ignition, or detonation, of explosive materials confined either in massive guns or in portable fire-arms. The explosive substance, whatever its nature, is rapidly transformed into a large volume of gas; this change is accompanied by the development of intense heat; and this heat vastly augments the expansive energy of the gaseous volume. It is the enormous effort made by the gases to attain their full volume—usually equal to a pressure of several tons on the square inch—which, being sufficiently resisted in other directions, is concentrated upon the projectile, driving it through the bore of the fire-arm with the force to which its subsequent range of flight and wounding power are directly due.

The gunshot injuries which occasionally occur in civil communities do not differ in any essential particulars from those which are inflicted in warfare, but ordinarily the missiles by which they are produced are such as are used for purposes of field-sport, and are therefore individually of very small dimensions.

The term 'Gunshot' injuries might at first appear to restrict the hurts so denominated to those which result from projectiles discharged from some of the various kinds of guns and fire-arms in common use. But injuries resulting from missiles projected

For Notes see Appendix at end of work.

by violent explosive force, under a variety of conditions, where no kind of gun is employed, are equally comprehended under the same term in military practice. Wounds produced by the fragments of a shell, or of any other metallic case containing an explosive powder, the charge or contents of which are fired, accidentally or otherwise ; or by fragments of fougasses, and other contrivances sunk in the ground, and designedly prepared for the infliction of wounds; wounds resulting from stones or other substances propelled by the explosion of military mines, or by the discharge of torpedoes ; although nothing of the nature of a gun is employed with them, are ordinarily described in military returns as 'Gunshot Injuries.' Up to a comparatively recent period, in all these instances, the explosive material from which the wounding power has been derived was the ordinary black gunpowder; but, now that other explosives are in use, even this source of authorisation of the term is wanting. And, indeed, as regards the essential characters of such injuries, surgically regarded, it matters not from what machine the missiles producing them are discharged, or from what material the explosive force arises; neither gunpowder, guns, nor specially formed shot are absolutely necessary to their production; any substance propelled with a sufficient amount of velocity, and therefore violence, by a sudden expansive force, may inflict injuries of precisely the same nature as injuries from gunshot. There is no difference in the effects of a shot from an air-gun,[1] and one from an ordinary fire-arm, when the rates of velocity impressed on the projectiles and other conditions are alike. The fragments of a water-shell, or of a close iron vessel rent into pieces by the expansive force of steam, are capable of causing injuries of precisely the same nature as those caused by the fragments of a shell burst asunder by gunpowder. It is the combination of conditions by means of which combatants have succeeded in impressing on projectiles, specially formed for penetrating the human body, an intensity of active force, or energy, otherwise unattainable, that creates the particular surgical interest which attaches to gunshot injuries when they are individually considered ; it is the peculiarity of the circumstances under which they usually take place, and have to be dealt with, as they occur collectively in warfare, that gives rise to the need of special study of them and of their treatment by army surgeons.

The present work is chiefly devoted to the study of gunshot wounds, as they are liable to come under the notice of surgeons engaged in military practice ; but I have thought it well to include observations upon the general features of wounds produced by fire-arms of all descriptions, not only by those employed as offensive weapons, but also by those which are commonly used for purposes of field-sport and amusement.

Nomenclature.—The word *Gun*, in the surgical term 'Gunshot Injuries,' has not the limited signification to which it is restricted in military phraseology, but includes fire-arms of all descriptions. It is synonymous with the French 'arme-à-feu,' as the term 'Gunshot Injuries' is with 'blessures par armes-à-feu.' The French were for a long time more precise than ourselves in their divisions of the 'blessures,' or hurts, into 'contusions par armes-à-feu,' contusions by fire-arms, and 'plaies d'armes-à-feu,' open wounds by fire-arms; the English expression 'gunshot wounds' having been commonly employed both for simple contusions as well as for open wounds. A proper distinction between the general term 'injury,' and the specific terms 'contusion' and 'wound,' was made in the authorised 'nomenclature of diseases' of 1868, and there is no likelihood of the terms being employed otherwise than according to their strict signification in future.

As by far the largest number of wounds resulting from fire-arms in warfare are caused by bullets from portable fire-arms, muskets and rifles, and as these are the wounds which have most engaged the attention of military surgeons, it might have been supposed that these weapons would have furnished the general name for the class of injuries under consideration. The surgical phrase *Gun*-shot injury, however, owes its origin to large guns (mortars and cannon) having been the first kinds of offensive weapons depending upon the action of gunpowder which were used in warfare, and also to the fact of the first *portable* fire-arms having been called 'hand-guns,' from their being almost identical in shape and construction with the guns of larger size. Nearly two centuries elapsed after the employment of guns before muskets were introduced, and nearly three centuries before they were established as regular instruments of warfare. Although in time they came to be the most frequent sources of wounds in military operations, English surgical writers, when describing fire-arm injuries, still continued to make use of the phrase which had originally been adopted shortly after the employment of guns and gunshot, and long familiarity with it still makes it the most convenient to employ.

General nature of gunshot injuries, and the principal features which distinguish them from other injuries having affinity with them.—Regarded as a group of bodily lesions, gunshot injuries comprehend every kind and degree of hurt which is capable of being produced on the human frame by the mechanical impulse of obtuse bodies: *non-penetrating contusions*, from the merest bruise of the surface, to others where, although the superficial structures remain unbroken, deeply seated organs are pounded into pulp; and *penetrating wounds*, from the slightest division of the skin, to wounds causing instantaneous death by total destruction of the organism.

The whole group naturally finds its place within the general

class of 'Contused Injuries.' The first set, indeed, non-penetrating gunshot injuries or contusions, differ in no respects from the contusions produced by blows of equal severity from other blunt instruments. When a fragment of shell, a spent bullet, or other projectile of low velocity, impinges upon part of the surface of the body, the condition of the structures which are injured by the missile is precisely similar to what it would be if the same part had been struck by any other obtuse body, of like size and weight, armed with the same amount of force. It is only, however, in rare and exceptional instances that *open* contused wounds inflicted by other instruments than those which are propelled by great explosive force, present the features characteristic of gunshot wounds.[2] Such instances do occur. The trunk or limb of a person brought into collision with part of a railway carriage moving at 'express' speed is destroyed in the same way as it would be if struck by a massive projectile; and men and animals are recorded to have been killed on certain occasions in tropical countries by large hailstones striking them with the accumulated momentum resulting from the force of gravitation, just as if they had been shot by a missile discharged from a fire-arm. Ordinary contused wounds, however, being for the most part produced by agents moving at relatively low rates of speed, are wounds complicated with over-stretching of the divided parts and adjoining structures; if very severe, are accompanied with more or less textural lacerations and ruptures extending far beyond the open wound itself, perhaps with complete disintegration of some of the structures concerned; but they are rarely, if ever, attended with that complete attrition and displacement, and even total removal of substance, which are so constantly characteristic of wounds produced by gunshot. A wound inflicted by a rifle bullet at high speed, through some of the softer tissues of the body, leaves an open empty track through which the projectile has passed; the walls of the track, or a portion of them, are devitalised by the action of the projectile; disintegrated pulp and dead shreds of tissue, which have been broken up and forced aside by the bullet in its passage, are jammed into these walls; while scarcely any bruising of the surrounding structures beyond is rendered visible, or indeed is produced. The same bullet may so glance along the surface of the head as to leave an open furrow from which the hair, scalp, pericranium, and a portion of bone will have disappeared, they having been carried away and dispersed by the bullet in its flight. The larger and heavier the rifle-bullet, the more obvious are these effects. A fragment of shell, at high speed, coming into collision with the soft parts of a limb, leaves a gap just as if the structures detached from the wounded surface had been scooped out by some cutting, though blunt, instrument. Portions of tendons, nerves, and ligaments, which, as a rule,

escape destruction in the most severe contused wounds produced by ordinary blunt instruments, are liable to be completely destroyed and removed by the action of projectiles. It is this complete attrition, separation, and dispersion of parts of natural tissues opposed to projectiles, together with the existence of certain complications and special features with which gunshot wounds are generally combined, as will be noticed hereafter, that particularly distinguish them from ordinary divisions of parts accompanied with a certain amount of structural bruising or crushing, and that, further, justify their usual separation into a distinct group, almost as much as the peculiarities of the projectiles to which they generally owe their origin, or the special circumstances under which they are presented to surgeons in military practice.

CHAPTER II

AGENTS CONCERNED IN THE PRODUCTION OF GUNSHOT INJURIES

Preliminary remarks.—It was stated in the preceding chapter, when giving a definition of gunshot injuries, that these hurts are usually produced by (1) an explosive compound confined and fired in a special way, in order to provide the necessary force; (2) a weapon, or closed case, usually contrived so as to give the required direction to this force, and also to the projectile upon which the force is intended to act; and (3) a body which, being propelled by the force thus generated, becomes the missile upon which the bodily injury directly depends.

In order to study gunshot injuries systematically, it is necessary to consider within certain restricted limits each of the agents which combine in producing them. The first two, however, viz., the explosive compounds and the fire-arms or other instruments employed for causing the wounds, need only brief remarks in this work. The projectiles to which the injuries are directly attributable are the agents of greatest interest to surgeons, and they must be described and illustrated at greater length. The guns and weapons from which they are discharged can be most conveniently noticed at the same time as the projectiles themselves. The explosive compounds will be treated of in the present chapter.

On the Explosive Compounds employed with Fire-arms, Hollow Projectiles, and other Military Contrivances.

The explosive compounds chiefly in use.—Various explosive compounds have been employed for propelling projectiles from fire-arms, for bursting shells, for exploding fougasses and mines,

and for other military purposes. The chief of these are gunpowder, fulminates, and certain chemical compounds. The many serviceable qualities of gunpowder have caused it to be the explosive agent constantly employed in past wars with fire-arms. Fulminating powder has only been used for a few special purposes. Of modern fire-arm explosives, there are a very large number of varieties; a few of the more important among them only will be noticed in the present chapter.

Gunpowder.—Depending, as gunshot projectiles in a large proportion still do, on the impelling force of gunpowder for their velocity, and consequently for their destructive energy, it will be well to consider briefly what the nature of this force is. So many injuries occur from the action of gunpowder itself when exploded, such as concussions, contusions, lacerated wounds, and burns, and instances of particles of unexploded gunpowder accidentally lodging in parts of the body are so frequent, that its composition and some of its chemical properties may also be briefly called to mind with advantage.

Without referring to its discovery, or its application to military purposes, both of which seem to be involved in great obscurity, it may be noticed as a curious fact that certainly for five hundred years it has been composed of the same mixture of ingredients as at present, viz., nitrate of potash, or saltpetre, charcoal, and sulphur, though not always in the same proportions, nor manufactured in the same manner. In the composition mentioned, the charcoal supplies the fuel, the saltpetre provides the oxygen for its ignition, while the combustible sulphur causes the ignition to take place more speedily, and renders the combustion more complete. The gunpowder used with early fire-arms was very irregular in its effects, and comparatively weak, from being made of impure ingredients, and from being used in the form of a fine powder, such as is now known as 'meal powder.' Some time elapsed before it was made in the form of coarse grains. Its strength was greatly increased by this change, owing to the opportunity it afforded for the free passage of flame among the particles, and to the ignition in consequence not being limited merely to the surface of the charge of powder, as it had previously been. Other changes have since been made in the manufacture of gunpowder, all tending to increase its force, and to make this force more manageable under the circumstances to which it has to be applied in warfare.

The proportions of the ingredients of the gunpowder made in England have very constantly been, of nitre 75 parts, sulphur 10, and of charcoal 15 parts; but in some gunpowder of recent manufacture the proportions of the nitre and carbon have been increased to 79 parts of the former, and 18 of the latter, while the sulphur has been reduced to 3 parts. This has been called

'brown gunpowder,' to distinguish it from the old 'black gunpowder.' Improvements have been made in the manufacture of gunpowder, so that perfect sameness of quality has been obtained, and uniformity of effects secured when like quantities are fired. Various forms, dimensions, weights, and degrees of density have been given to the separate 'grains,' in order to adapt their modes of ignition and rates of combustion to guns and fire-arms of different sorts and sizes, and thus to fit the agent to the work that has to be done by it with scientific accuracy. It would be out of place in a work of this kind to attempt to describe the steps which have been taken to attain these results; but it is important for surgeons to know that they can accept as a fact that equal rates of velocity are impressed on projectiles by equal charges of the same kind of powder.

The chemical qualities of the several ingredients of which gunpowder is composed are too well known to need mention. Their innocuous character when brought into contact with the tissues of the human frame was fully established as early as the time of Ambrose Paré, who demonstrated that gunpowder had no hurtful effects when swallowed, and was unable to impress any noxious qualities on projectiles such as to influence the wounds caused by them. Daily proofs are afforded, if any were wanting, of the local inertness of gunpowder by its employment in tattooing, and its lodgment with impunity in scattered grains in the skin and subcutaneous tissues of persons exposed to accidental explosions, in which some particles of the gunpowder are generally projected unfired.

Gunpowder explodes at a temperature of about 700° Fahr. When free, in open air, it burns rapidly away, or deflagrates, with much smoke, but little noise; when confined, it explodes with a loud report and much force. The force of the explosion, resulting from the production of gases expanded by the intense heat developed by the chemical action between the combustible ingredients and the nitre, varies according to the conditions under which the gunpowder is fired. Variations in the density of gunpowder, and also in the shape and size of the several grains,[3] cause its explosive force to be developed in greater or less time as required. The fact that the gases resulting from the explosion can be made to expand more or less gradually, so as to continue their impulsive action on the shot while it passes along the gun, specially distinguishes gunpowder from fulminates, and from all highly sensitive explosives. The total amount of gas resulting from the explosion occupies about 250 times the volume of the original powder. A certain amount of water exists, combined with the nitre and charcoal, and the conversion of this ingredient into steam — superheated steam — increases the gaseous volume. The temperature of the flame produced by the combustion has

been variously estimated at from 2000° Fahr. to 4000° Fahr., and as the gaseous volume is repeated for every 480° Fahr. of temperature, its increase from expansion by the heat generated during the combustion has been variously estimated from about four to eight times that of the original volume. If the former increase be accepted, the force of the explosion will be in round numbers equivalent to 1000 atmospheres, or to a pressure of 15,000 pounds on the square inch; if the latter be accepted, to 2000 atmospheres, or 30,000 pounds on the square inch. The energy of fired gunpowder has been estimated to be even still higher than what has just been named.[4] The force impressed on a rifle-bullet by the explosion of an ordinary charge of powder, as of massive projectiles by proportionally increased charges, thus becomes readily intelligible when the enormous amount of pressure to which it is suddenly subjected in the fire-arm is duly considered.

The chemical results of the explosion of gunpowder are 32 per cent. of gaseous products, 68 per cent. of solid residue. The principal gases evolved are carbonic oxide, carbonic acid, nitrogen, and aqueous vapour; the solid residuum consists chiefly of sulphate, carbonate and nitrate of potash, with hyposulphite of potassium and a little unconsumed charcoal. The smoke has nearly the same composition as the residuum just mentioned.

Fulminating powder.—The only fulminate used for military purposes is the fulminate of mercury. It is chiefly employed for charging percussion-caps, and for use as a 'detonator' in exploding gun-cotton and other high explosives.[5] This highly sensitive fulminate explodes instantaneously and violently by friction or percussion, though, unlike some other fulminates, it burns away quietly when kindled in the open air. It explodes when heated to a temperature of 360° Fahr. The instantaneous conversion of the fulminate into a large volume of gas, and consequently its extremely violent and sudden percussing force even in very small quantity when confined, are its distinguishing characters. The gases resulting from the explosion are carbonic acid, nitrogen, and vapour of mercury. In the celebrated Orsini attempt on the life of the French Emperor in the year 1858, the three shells thrown were filled with fulminate of mercury. Each shell contained upwards of four ounces of the fulminate. The shells were broken up into very numerous fragments, and led to the infliction of 511 wounds in the 156 persons who were injured by the explosion.

Smokeless powders.—Certain chemical compounds possessing explosive qualities, but differing in many important respects from the gunpowder previously described, are now employed as substitutes for it in most European armies. They are known under a variety of names, but the chief of them have either some form

of gun-cotton (nitro-cellulose), dynamite (nitro-glycerin), or picric acid (tri-nitro-phenol) as a basis. As they emit, when exploded, very little smoke by comparison with black or brown gunpowder, they are commonly spoken of as *smokeless powders.* Repeated trials have been made in England of such chemical powders or high explosives with a view to discover one as trustworthy and uniform in its explosive effects as the gunpowder hitherto in use. Obviously any such powder, to be suitable for British military purposes, must be capable of being stored for years without any gradual chemical change occurring in the materials composing it; must be perfectly stable under such climatic conditions as extremes of dryness and moisture, heat and cold; and must not be liable to explosion from friction when handled, or from concussion during transport by sea or land. A substance possessing all these qualities, it is believed, has been discovered in the explosive recently authorised (1891) for use with the Lee-Metford rifle and other guns, under the name of 'cordite.' Some of the special features of a few of these chemical powders are described in the following observations.

Gun-cotton (Tri-nitro-cellulose).—Great efforts were made after the discovery of gun-cotton in 1846 to manufacture it in such a way that it might be safely applied to fire-arms as a substitute for gunpowder. Although this object was not satisfactorily attained in the British service, compressed gun-cotton was employed for many important purposes, especially in engineering operations. As far back as the year 1870 it was included among the regular stores of the army, and was ordered to be dealt with under the same precautions as filled shells when carried by sea.[6]

The early experiments with this extremely sensitive agent, were attended with so many disastrous accidents both in England and abroad, that there appeared to be at that time little probability of its ever being brought into general use for military purposes; but means have since been discovered of so controlling its dangerous qualities, that now it seems to be as reliable and manageable as gunpowder. This control was obtained in some degree by a plan of structurally arranging the material, devised by Baron von Lenk, of the Austrian service; but was afterwards more effectively accomplished by Mr. Abel, of Woolwich, who reduced the gun-cotton to pulp, like the pulp of paper, and after purifying it from all free acid, diluted it, according to circumstances, with less explosive materials, and compressed it into charges of the required forms and consistence. This prepared gun-cotton, with certain modifications, is now employed as a substitute for gunpowder with fire-arms.

Compressed gun-cotton, as it is used for large military operations, in mining, and for various destructive purposes in war, is

always transported and stored in a wet state—about 20 per cent. of water being ordered to be the minimum. In this state it is quite uninflammable, both under concussion and percussion, and can be kept for any length of time in any climate without undergoing spontaneous chemical change. It can, however, be detonated by suitable primers of dry gun-cotton and charges of fulminate. After gun-cotton has been kept in the wet state, if dried, it is as efficient in all respects as an explosive as it was previously.

The principal qualities which give a superiority to gun-cotton over gunpowder as an explosive for military purposes, are the absence of smoke and of fouling. The gaseous results of the explosion of gun-cotton are almost transparent, and no solid residuum remains; thus contrasting greatly with gunpowder, which leaves about two-thirds of solid residue when fired. Gun-cotton when fired in a loose state gives out vapour of nitrous acid, but only in a very small quantity; when fired under pressure, in the manner in which it has been prepared for fire-arms, is said to yield none at all. The principal products of its combustion under these circumstances are carbonic acid, carbonic oxide, nitrogen, a small amount of hydrogen, and aqueous vapour. There is also some product which occasionally emits a very unpleasant odour.

The use of gun-cotton is calculated to facilitate military operations in other ways besides its freedom from smoke and fouling. The disruptive force, as for bursting shells, is six or eight times greater than that of gunpowder; its propelling force as a charge in fire-arms is about three times greater, one part by weight in gun-cotton carrying a shot as far as three times the same weight in gunpowder. It explodes at a temperature of about 277° Fahr. The character of the explosion varies according to circumstances. When ignited in a free state in the open air, gun-cotton burns like an ordinary inflammable substance; when it is confined and ignited by the intense sharp action of a detonator, such as by a fulminate, it explodes almost instantaneously with extreme violence and with scarcely any visible flame; but when pulpified with the addition of certain non-explosive ingredients, compressed, and dried, its combustion is retarded, its excessive disruptive violence is lessened, and it explodes after the manner of gunpowder. It does not, however, heat guns, as the explosion of gunpowder does. The 'Schultze gunpowder,' now so much used with sporting guns, belongs to this, the nitro-cellulose, class of explosives. Wood-fibre is substituted for the cotton, and some other ingredients are included in its composition.

Nitro-glycerin.—The explosives which depend on nitro-glycerin for their efficiency are very numerous, but the composition known as 'Dynamite' is the one most generally known. It is extensively used for the purposes of civil life, but is also

employed in many military operations, particularly for destroying obstacles of all kinds, for blowing up buildings and bridges, and also as a bursting charge in shells. A plan of preparing it was devised in England, which rendered it almost free from danger when transporting it from place to place. This immunity was obtained by a process similar to that by which Mr. Gale rendered gunpowder non-explosive at pleasure, without injuring its explosive qualities when wanted for use. He temporarily mixed the gunpowder with a sand-like incombustible substance, viz., a certain proportion of granulated glass. In the case of the nitro-glycerin some fine siliceous earth is mixed with it—usually about one quarter by weight of the inert earth with three-quarters by weight of nitro-glycerin. The composition thus diluted will not explode, either under the action of heat or simple concussion. When set fire to in free air, it burns without any report or explosive action, without smoke, and with a flame resembling that of alcohol. But by means of a fulminate through which it is suddenly subjected to the conjoint action of the heat of a spark and of violent percussion, it explodes with great violence. Its explosive force under such conditions is said to be about eight times in excess of that of gunpowder. In a shell, therefore, sufficient dynamite for filling the eighth part of the space that would be required for a charge of gunpowder would produce the same bursting effect; and by increasing the quantity of dynamite, and making the shell proportionably thicker, without altering its diameter, the fragments into which it would become broken on explosion would be more destructive on striking any resisting objects which might happen to be opposed to them.

Dynamite is at present manufactured in large quantities for blasting purposes, and the composition of several varieties is regulated by legal enactments. One of the most recent kinds is designated 'blasting gelatin,' and is made by dissolving nitro-cellulose in nitro-glycerin under such conditions that the two substances form by their union a stiff jelly. This gelatinous substance forms a very powerful explosive; but the rapidity of development and energy of its explosive qualities can be regulated by varying the proportions of its components, and by the addition of certain ingredients. These gelatin explosives are sometimes divided into short cylindrical rods or tubes, and put into cartridges of suitable sizes for use for blasting purposes; and it is stated that some forms are used on the Continent with guns.

All gun-cotton is not soluble in nitro-glycerin. The tri-nitro-cellulose, or highly explosive gun-cotton, will not do so. By altering the modes of preparation, less explosive forms of gun-cotton can be manufactured, and it is one of these forms,

after being dissolved in a mixture of alcohol and ether, that constitutes the collodion used in surgical practice. This soluble form of gun-cotton can be dissolved in nitro-glycerin, and thus be made to assume the characters of one of the blasting gelatin explosives.

Cordite.—This explosive material, invented by Sir Frederick Abel and Professor Dewar, and arranged for use with the Lee-Metford rifle ammunition, is an explosive of the 'blasting gelatin' species. As made up in the cartridges for the Lee-Metford rifle, the cordite charge presents the appearance of a bundle of yellowish-brown, flexible, semi-translucent threads or rods, each one inch and three-quarters in length. The strands of cordite are very like pieces of fine catgut, and give much the same sensation to the fingers on being handled as catgut string does. Externally there is no noticeable difference between a cordite cartridge and one of black gunpowder. A single cartridge contains 30 grains of cordite. The relatively greater explosive power of the cordite is sufficiently shown by the fact that whereas 30 grains of the cordite suffice to impress on the bullet when it leaves the muzzle of the rifle a progressive velocity of 2000 feet in a second, a charge more than double in weight, viz., 70 grains, of compressed gunpowder gives a velocity of translation at the muzzle only of 1850 foot-seconds. When a strand of cordite is placed on porcelain and ignited in the open air, it deflagrates like saltpetre, and the flame runs gradually, with a slight fizzing noise, from end to end without causing smoke. After the flame has passed away, a brown substance sticking firmly to the porcelain is left behind, and this, on being highly magnified, is seen to be translucent or glassy, and studded with minute black spots of carbon.

As before mentioned, explosive gun-cotton (tri-nitro-cellulose) is not soluble in nitro-glycerin, under ordinary circumstances; but with regard to cordite, it appears that the inventors have discovered means by which the explosive gun-cotton can be antecedently so acted upon as subsequently to be rendered capable of solution in nitro-glycerin, and to become gelatinised without impairing its highly explosive qualities. Cordite is thus superior in explosive power to 'blasting gelatins' in general.

Picric explosives.—A considerable number of patented explosive substances, some used with small arms and guns, others for blasting purposes, depend upon picric acid, or on some of its salts, for their energy. Picric acid is a compound derived from phenol (carbolic acid), a portion of its hydrogen being replaced by nitric peroxide, through the action of nitric acid on the phenol. The French 'melinite' belongs to the class of picric explosives, but its exact composition has not been made public. In some accidental explosions of this substance in France, it was noticed as a peculiarity that the survivors of the wounded men had the

skin of those parts which had been subjected to the force of the explosion stained of a deep yellow colour. This yellow stain was regarded as characteristic of the melinite explosive.

How far the various chemical powders that have been adopted for ballistic purposes in Continental armies, and that undoubtedly consist of one or other of the violent explosives just described, modified either by chemical combinations or mechanical mixture with other ingredients, will fulfil all the expectations that are held regarding them, will probably only be known after they have been tested by the various trying conditions to which they will be subjected in actual warfare.

Compressed atmospheric air.—Compressed air, as it is employed in air-guns for the discharge of projectiles, approximates in its nature and action to the substances which constitute this class of explosives. It is never used for military purposes, and is only noticed briefly here because the shot from such guns are occasionally the cause of wounds in civil practice, though rarely so (see Note 1 in Appendix). As with regular explosives, it is by its sudden alteration in volume when the pressure to which it has been subjected is removed, and by the force derived from its very rapid expansion, that it acts upon the shot which is projected by its agency. It is in this respect that it becomes analogous to one of the solid substances, such as gunpowder, which, by being suddenly converted into vapour or gas, is used as an explosive agent. But from its nature, and from the conditions under which it is ordinarily employed, air-gas can never impart the amount of velocity to a projectile which is necessary for conferring on it sufficient energy to make it of general importance as a source of injury. The wounds which a projectile from an air-gun is able to inflict can only occur within very limited distances from the weapon.

CHAPTER III

ON THE FIRE-ARMS OR OTHER MACHINES, AND ON THE PROJECTILES CONCERNED IN THE PRODUCTION OF GUNSHOT INJURIES

For what reasons, and to what extent, acquaintance with this part of the subject is necessary for military surgeons.—A particular knowledge of gunnery does not concern military surgeons, but it is necessary for them to possess an acquaintance with the names and nature of the principal kinds of fire-arms and shot, and some of the peculiarities of their construction. Whatever increases in a marked degree the velocity of movement, force, and range of projectiles, whether it be alterations in the

projectiles themselves, or in the fire-arms from which they are discharged, changes proportionably the features of the injuries inflicted by them, and within certain limits, the arrangements which require to be made for the transport, care, and hospitalisation of the wounded in case of the occurrence of war. The military surgeon ought therefore to have some knowledge of the modes of movement, of the rates of velocity and other characteristic features of projectiles, for he cannot have a correct understanding of the nature of the injuries inflicted by them without it. The knowledge further enables a surgeon to recognise and describe more correctly the various kinds of injuries which he meets with in practice; and it is to be remembered army surgeons are required to specify in the tabular and numerical Returns of Wounds, which have to be furnished after engagements, the particular projectiles and weapons by which the wounds have been caused.

The student of gunshot injuries requires, further, to know something of the history of the successive changes which have taken place in fire-arms and fire-arm projectiles from time to time, so that he may be able to understand the different descriptions of the injuries produced by them which have been given by surgeons at different periods. It would be difficult for a surgeon whose observations were solely derived from witnessing the effects of the projectiles used in warfare at the present time, to understand some of the observations of the celebrated John Hunter on the subject; neither would many passages in the writings of army surgeons engaged in practice during even so comparatively recent a period as that of the Peninsular War, be clearly understood without the student being acquainted with the qualities of the guns and projectiles by which the wounds were at that time inflicted. But it is only so far as they may be supposed to have exerted an influence on the special features of the wounds caused by them that a knowledge of the changes which have taken place in the construction and arrangements of fire-arms possesses professional interest for military surgeons; and such matters will only be so far noticed in the present work as to meet the requirements which have just been mentioned.

General classification of projectiles considered as sources of gunshot injuries.—Gunshot injuries are produced by two classes of projectiles: *direct* projectiles, those which are projected directly by a *primary* explosive force; and *indirect* projectiles, those which are secondarily impelled by projectiles of the former kind, and are subsequently brought into collision with the persons wounded by them.

A direct projectile has impressed upon it at first starting a momentum corresponding with the whole of the force by which it has been discharged from the fire-arm, or has been otherwise

projected; an indirect projectile has impressed upon it at first starting only so much momentum as the force retained by the direct projectile at the instant of striking is capable of imparting to it, *minus* the force which has had to be expended in overcoming its inertia or the resistance met with in propelling or rending it from the situation it had been occupying previously to its removal.

Of the *direct projectiles*, some have definite, others indefinite forms. The projectiles which have definite shapes are the several varieties of shot for smooth-bore guns, shell (before explosion), rockets, grape-shot, with the cast-iron balls or sand-shot, and bullets contained in case-shot; together with the various kinds of bullets and shot discharged from machine guns, and portable arms, such as rifles, carbines, and pistols. The direct projectiles of indefinite shape are such as result from the explosion of fougasses, torpedoes, mines, tumbrils, magazines, or from the bursting of any case by the firing of explosive materials enclosed in it, when the case itself has not been previously set in motion by some primary force of impulsion. When shells, discharged in the ordinary way, are burst asunder, the fragments, and the contents of the shell, if any exist, cease to possess purely the characters of direct projectiles, for the primary forces by which they have been projected are to a certain extent modified by the effects of their bursting charges, as will be notified hereafter.

The *indirect projectiles* which give rise to injuries in warfare are very various in their nature: stones or other hard substances struck from parapets, or from the surface of the ground, by gunshot; splinters of iron and wood torn in a similar manner from guns, gun-carriages, platforms, embrasures, timbers of ships, &c.; parts of metal accoutrements, fire-arms, and other articles carried by soldiers; even portions of the bodies of wounded comrades; together with fragments of a variety of miscellaneous objects employed in warfare, or happening to be near to the troops, which have been struck and scattered by shot or shell in the course of their flight.

Extraneous substances accompanying projectiles in gunshot wounds.—Portions of clothing or other articles worn or carried by wounded persons, or fragments of bones or other parts of the bodies of the wounded men themselves, when they have been detached by projectiles and are forced into parts to which they do not naturally belong, cannot properly be regarded as being projectiles, even of the indirect kind. They do not produce the wounds. Such lodged substances are with more propriety classed among the primary complications of gunshot wounds.

Classification of particular projectiles.—The projectiles discharged from fire-arms may be most conveniently considered in a surgical work under two groups, viz.:—

(A.) *Large projectiles*, discharged from heavy arms of large

calibre, such as guns, howitzers, mortars, &c.; or otherwise propelled, as rockets; and

(B.) *Small projectiles*, discharged from machine guns with barrels of small calibre, as the Maxim, Gardner, Gatling, and Nordenfelt guns, or from portable fire-arms, such as rifles, carbines, and pistols.

CHAPTER IV

LARGE GUNS AND THEIR PROJECTILES

Guns.—Only a few general remarks are necessary in respect to the guns from which the larger kinds of projectiles are cast, as their shapes and particular mechanical construction have not the same influence on the *features* of wounds as the like qualities have in smaller kinds of fire-arms. The improvements which have been made in them, as in the smaller kinds of fire-arms, have had for their chief objects increased power of projection, accuracy of aim, and facilities for multiplying the quickness of fire.

Guns, or, as they were originally called, bombards,[7] afterwards popularly designated 'cannon,' are the oldest kind of fire-arm. They were originally like mortars in shape, being wider at the mouth than in the bore or at the breech. Guns are stated to have been used in the English army, under Edward III., as early as 1346;[8] some writers mention a still earlier date. They appear to have been often cast of immense size,[9] and to have been at first made more with a view of throwing huge stones and battering the buildings of besieged places, than with the intention of inflicting wounds among troops in the open field. The alterations in guns since the early periods just referred to, have gradually given them a more scientific construction; but it is not necessary to follow them through these changes. Guns of enormous weight and dimensions have been constructed of recent years. One of the latest in England has been the 81-ton gun, 27 feet long, with a bore of 16 inches, expending a charge of powder of above 300 lbs., throwing a projectile 1700 lbs. in weight, and striking a blow of 26,300 'foot-tons.' But this has been outdone by the 100-ton gun, with its projectile, 2000 lbs. in weight, and a developed striking energy of 31,000 foot-tons. The power of projection attained by gunnery is shown in the instance of a gunshot described by Major Barker, R.A., in a lecture on 'Modern Gunpowder as a Propellant,' delivered at the Royal United Service Institution, in January 1890. The weight of the projectile alluded to was 380 lbs. It

started with a muzzle velocity of 2375 feet per second, rose to a height of 21,263 feet, and had a range of 21,800 yards, or over 12 miles.[10] The struggle in these directions does not, however, much concern surgeons; the wholesale ruin and destruction these gigantic weapons are designed for, if accomplished, will leave no scope for surgical help. Moreover, the projectiles used with these monstrous guns are not prepared for acting directly against troops; they are chiefly designed for clearing away obstacles, destroying solid substances, as earthworks, for sinking the ships of invaders; they are not what are sometimes described by artillerists as 'man-killing projectiles,' and if men are killed or wounded by their action, this is only incidental to the accomplishment of their primary purposes.

Large projectiles.—As regards the projectiles discharged from field-guns, and employed against troops, the surgeon will not fail to notice that the changes which have been successively made in their construction have each increased their power of destructiveness, particularly in respect to the number of wounds and injuries inflicted by them. Thus, from the imperfectly formed stone or iron round shot of the earliest periods, inventors proceeded to fashion simple shells, which were again followed by the more perfect shrapnell and segment shells and case, each successive improvement in these projectiles being specially designed and contrived for increasing the number of injuries capable of being made by them. The more destructive qualities of the projectiles themselves, together with the increased force of their projection, as well as the increased facilities of rapid fire which have been obtained by the improvement in the guns from which they are discharged, have caused the area of injury as well as the numbers of killed and wounded to be greatly magnified within given periods of time, and have augmented the difficulties of surgical administration, so far as the interests of the wounded are concerned.

Although there are few of the large projectiles which were in ordinary use a few years ago that are not now passing away, modern forms being almost wholly confined to cylindro-conoidal shells and cylindrical case-shot, yet a brief description of them is of historical interest, and indeed necessary, for they are constantly referred to in the works of the best writers on military surgery of the present century. Many of them, too, are still to be met with, kept ready for use under certain special circumstances.

The projectiles of large size used in warfare have been technically distinguished under the names of shot, shell, carcass, and rockets. Numerous varieties of each of these classes of projectile have been in use, with the exception of the carcass. Examples of the leading varieties only will be noticed.

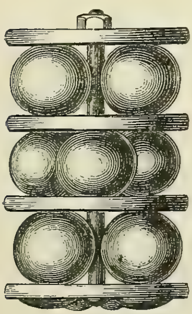
Gunshot of smooth-bore guns.—The ordinary gunshot formerly in use were formed of solid masses of cast iron; the larger kinds being projected singly, the smaller kinds collectively. They were spherical in form, and hence were often called *round shot*,[11] or, popularly, 'cannon-balls;' with the Whitworth guns they were hexagonal, either with tapering ends or flat-headed, and were often spoken of as *bolts*.[12] The larger, so-called *loose*, projectiles, fired singly, varied in weight in the British service from a shot a little under 3 lbs. in weight for a three-pounder gun, to that of the twelve-inch gun, 600 lbs. The smaller kinds, fired collectively, varied from 1 oz. to 3 lbs. in weight.

Spherical projectiles in the very early days of big guns were made of stone, but subsequently for many years they consisted of solid spheres of cast iron. Occasionally they have been made of cast steel or of chilled iron (*chilled shot*). Solid shot were sometimes heated to a red heat before being fired. They were then used against shipping, magazines, or buildings, more for incendiary purposes than for inflicting wounds.

The smooth-bore guns, from which these spherical projectiles were fired, are no longer in use by field-artillery, and the shot employed with them have therefore become obsolete. Spherical projectiles are only retained in the service for use with some siege and heavy guns against masonry, and a few other special purposes. They will probably disappear altogether from the catalogue of military stores before many years are past.

Grape-shot for smooth-bore guns.—Grape-shot for some years consisted of a certain number of round cast-iron shot, nine or more, according to the size of the projectile, held in three layers between four tiers of flat circular iron plates. These plates were connected by a central rod or spindle, the latter being secured at one end by a nut and screw. The iron discs had holes bored through them for receiving the shot, which were thus held tightly in their position. This projectile was known in England as Caffin's grape (fig. 1). It was largely employed by the Russians during the Crimean war in the defence of Sebastopol. The instant such a shot left the mouth of the gun, owing to the manner in which the explosive force was impressed on its different parts, the nut in front was forced off the screw, the plates, often distorted, successively followed, and both shot and plates were more or less scattered in their onward flight among the assailants. The discs soon fell to the ground in consequence of the resistance of the air, while the shot had a considerable range.

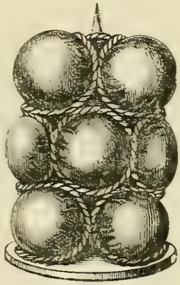
Fig. 1.



Caffin's Grape.

At a former period, these projectiles were made up in canvas bags, and the bags being tied round and round, 'quilted,' so as to secure the shot from shifting out of their respective places, an appearance somewhat resembling a bunch of grapes was presented—hence the name (fig. 2). This was the grape-shot which was in common use in the British service during the Peninsular and other wars of the present century prior to the Crimean war, and to which reference is frequently made in the accounts of naval actions of the same period. Old stores of this projectile were turned to account in the British army during the Crimean war, though the kind known as Caffin's grape was chiefly employed.

FIG. 2.



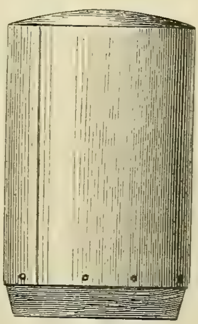
Quilted Shot.

Grape-shot varied in weight according to the size of the gun from which they were intended to be discharged. In a 32-pounder gun the weight of the whole shot was 36 lbs. 4 oz., the nine grape comprised in it each weighing 3 lbs., and the plates, spindle, and screw, 9 lbs. 4 oz.

The manufacture of this form of projectile is discontinued, but Caffin's grape is still ordered to be employed for land service when it may be found advantageous to use it. For general purposes it is superseded by shrapnell and case shot.

Case, or canister, shot for smooth-bore guns.—These projectiles have not been much changed in adapting them to modern guns. They have always consisted of closed cylindrical canisters or cases (fig. 3) made of thin sheet-iron, and filled with cast-iron balls of different sizes according to the nature of the shot employed. From the same causes that led to the separation and dispersion of grape-shot, the canister holding the encased shot was torn asunder at the moment of quitting the gun's mouth by the shock of the discharge, and its fragments and the liberated shot which had been contained in it were then forced onwards independently, the scattered shot assuming, as a whole, the area of a cone. The destructive effect of case-shot was confined to comparatively short distances—from 300 to 350 yards. They were principally designed for use against troops in close column, or when massed together, as in the assaults of besieged places.

FIG. 3.



Case-Shot.

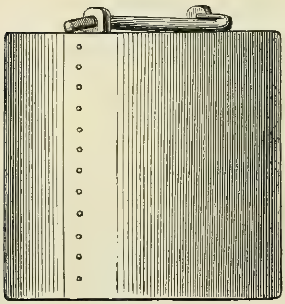
Case-shot were used of various sizes, and the projectiles within the case were also of various weights. The case-shot for a 32-pounder gun weighed nearly 36 lbs.; it contained 66 shot, each shot being 8 oz., or a total of

33 lbs.; the iron case and wood bottom made up the remainder of the weight. In some kinds of case-shot, the contents consisted partly of 8-oz. shot, and partly of 1-oz. mixed metal bullets, which were arranged to fill up the spaces between the larger projectiles.

Wounds from discharges of 'langridge,' or 'langrel,' are occasionally alluded to in surgical reports, especially those connected with naval warfare. Langridge was case-shot in a primitive form. It appears that very early in the art of gunnery, artillerists employed charges of small stones, nails, and other irregular substances, packed together in bags, as projectiles under this name. Similar contrivances were frequently employed by the rebel sepoys during the Indian Mutiny, in default of projectiles of more regular form and construction. In some French forms of case-shot, small irregularly-shaped fragments of hardware, as pieces of iron, brass, and old nails, were, till lately, employed under the name of 'mitraille,' for service at close quarters, and this name is still retained in the French service for what in England is termed case-shot.

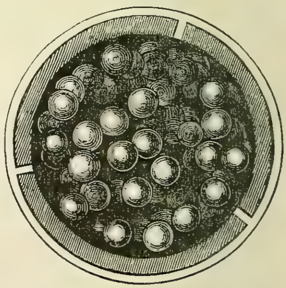
Case-grape or carronade-grape for smooth-bore guns.—This projectile is constructed on the same principle as the case-shot just described. The construction of the cylinder is altered, there being inside, in addition to the outer thin iron case, a loose circular iron plate at the base, and a thick inner iron cylinder,

Fig. 4.



Case-Grape.

Fig. 5.



Section of Grape Case.

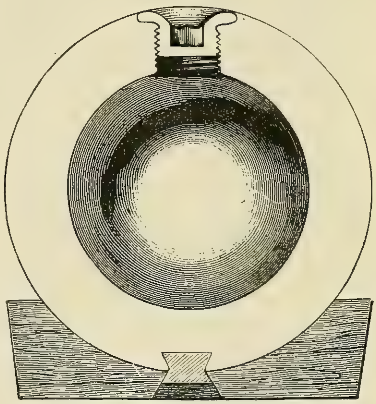
divided into three separate parts, so that there may be substance enough to contain the heavy iron balls within, and at the same time as little impediment as possible to the rending of the cylinder by the discharge shock (figs. 4 and 5). The general issue of these projectiles is discontinued, but they are ordered to be retained at out-stations for issue on occasions when likely to be of service.

Shells for smooth-bore guns.—Any hollow iron projectile adapted for enclosing a quantity of gunpowder, or other explosive material, and designed to be burst into pieces on this material being exploded, is called a 'shell' (fig. 6). Shells have

been projected from guns of various forms, from mortars, howitzers, guns of position, &c. They may be thrown by the hand; in which case they are designated *hand-grenades.*

The bursting charge is introduced into the interior through a circular opening in the shell. When the shell is prepared for use, the opening is filled by a tubular plug, called a 'fuze.' Ordinary fuzes contain a composition, which, being ignited by the flame emitted on the discharge of the gun, burns for a certain time and then ignites the bursting charge within the shell. The length of time during which the fuze composition shall burn before igniting the bursting charge is capable of being regulated; and thus the distance to which the shell shall travel before being burst can also be arranged by the gunner. Other fuzes are contrived for igniting the bursting charge when the shell strikes an object. These are called percussion fuzes. Formerly the bursting tubes were made of wood, now they are made of metal; these metal fuzes are not unfrequent sources of wounds when shells burst among bodies of troops. The walls of the common shells formerly employed with field-artillery usually burst into from twelve to about forty fragments of various weights and sizes. These fragments were scattered in all directions, radiating from the centre of the explosive force by which they had been torn asunder, and were thus calculated to inflict wounds among a number of men around the immediate vicinity of the exploded shell.[13] The weight of a 32-pounder common shell was 23 lbs. 4 oz.; the bursting charge consisted of 1 lb. of gunpowder.

FIG. 6.



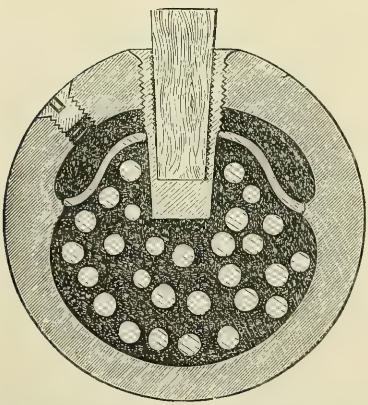
Common Spherical Shell.

Hand-grenades.—These projectiles do not differ in any essential particulars from the shells just described. The circumstance of their having been made about the size of a pomegranate, sufficiently small to be held and thrown by the hand, led to their receiving their special name. They are of two sizes, 6-pounder and 3-pounder grenades, and can be thrown by hand to a distance varying from 20 to 30 yards. The bursting charge of a grenade of the larger size is about 5 oz., of the smaller, 3 oz. of gunpowder. They are chiefly employed in sieges, for purposes of defence, when they are thrown from the parapets among bodies of troops making an assault, sometimes singly by hand, and occasionally

projected in numbers together from small mortars placed just behind the works at the spot under assault. In the year 1678, a company of soldiers armed with these projectiles was added to all British regiments, and these men were hence called 'grenadiers.' Each grenadier had a pouch of hand-grenades in addition to his firelock. This mode of carrying and using grenades ceased as far back as the reign of Queen Anne, but the name of 'grenadier company' has been retained to our own days.

Shrapnell shells for smooth-bore guns were at one time called 'spherical case-shot.' A shrapnell, as formerly used, was a shell filled partly with gunpowder, and partly with a number of hardened bullets of mixed sizes, and was fired direct from a smooth-bore gun, with a very heavy charge of powder to project it, while its own bursting charge of powder was so reduced in quantity as to be only just enough to break it asunder. The bullets were hardened by mixing a proportion of antimony with the lead. Shrapnell shells were usually arranged to burst while still possessing an immense horizontal velocity. This velocity, as a matter of course, was equally possessed by the bullets within the shells; and the bursting charge not being in quantity sufficient to scatter or turn them much aside, they pursued their onward course, after the shell had burst, with great force. They were thus calculated, on meeting a body of troops, to inflict a large number of severe wounds among them. Shells of this description get their name of 'shrapnell' from that of their inventor — General Shrapnell of the Royal Artillery.

Fig. 7.



Diaphragm Shrapnell Shell.

Diaphragm shrapnell shells.—It occasionally happened that the ordinary shrapnell just described burst prematurely. This appeared to be owing to the powder becoming ignited, either by the effects of friction of the bullets against each other, or against the interior of the shell, after the shell had been projected from the gun. To prevent this accident, Captain Boxer invented a shell in which the bursting charge was separated from the charge of bullets, and this was afterwards adopted in the British service. The separation is effected by a curved plate of wrought-iron (fig. 7), in a similar way that the cavity of the chest is separated from that of the abdomen, and hence the name given to the projectile. The arrangement of the diaphragm shrapnell

necessitates two openings, one for the insertion of the gunpowder, and one for the shot. The former is filled up, when the projectile is employed, by the bursting fuze; the other by a metal screw plug. The fragments of the shell and diaphragm join with the fuzes and shot in adding to the number of wounds that may be inflicted on troops when the projectile is exploded.

The efficiency of shells of the shrapnell kind chiefly depend on their rate of progressive motion, for the quantity of powder in the powder chamber is only just sufficient to burst the shell open. They are intended to burst at a height of ten or twelve feet above the ground, and at a distance of about fifty yards in front of bodies of troops.

The spherical forms of shrapnell are no longer issued for general service, but they still exist in some colonial stations.

Water-shells.—These shells, invented by Professor Abel, are common iron shells filled with water. Fixed to the base of the fuze is a metal 'burster' containing compressed gun-cotton, and having a small receptacle above for a detonator of fulminate of mercury. When the fuze is screwed in, this burster occupies the centre of the shell. On the fuze being ignited, the flame is communicated to the fulminate, and this in turn detonates the gun-cotton. An enormous force is instantaneously generated, which is communicated evenly in all directions by the water to the interior of the iron shell. The shell is broken up into a large number of fragments which are projected on every side. This shell, according to some published experiments, effected five times more hits against a target than when a shrapnell shell was used. One ounce of compressed gun-cotton in the burster broke a 16-pounder shell into 300 fragments, $\frac{1}{4}$ ounce into 121 fragments. The latter were considered to be the most suitable, as to size, for inflicting injuries.

Carcasses.—These projectiles are like shells, so far as they are hollow cases of thick iron, but are essentially different in purpose. They do not contain any explosive substance. A carcass is filled with a compact composition of a highly combustible nature. It is ignited at three openings in the shell by fuze composition which passes down into the carcass composition. The flames that issue from the burning composition through these openings are intensely strong, and will set fire to any combustible substance within reach. The light issuing from the flames is white in colour and very bright, so that carcasses are sometimes projected from mortars to light up positions at night from which attacks are expected, in the same way as light balls and parachute or suspended lights. A 12-pounder carcass burns for 3 minutes, a 13-inch carcass, 12 minutes. They were in frequent use for this purpose at the siege of Sebastopol.

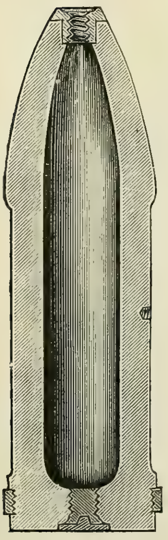
Rifled guns and their projectiles.—The manufacture of smooth-bore guns and spherical projectiles has been abandoned

since the introduction of rifled guns, and the old issues are now only retained for use under special circumstances. The projectiles used with rifled guns are similar in their general nature and purposes to those which were used with smooth-bore guns, as common shell, shrapnell shell, and case, but they are altered in their forms, and adapted in sundry particulars to the different condition of rifled armament. Like the old patterns, they vary in their dimensions, weights, and details of construction, according to the sizes and peculiarities of the guns from which they are fired. They are elongated and are nearly all cylindro-conoidal, or rather, as the front passes from one radius of curvature to another, cylindro-ogival in shape.

Some few of their characteristic features, with illustrations of an example of each class, will alone appear in this work; those who are desirous of more detailed information regarding such projectiles will find it given in works specially devoted to the subject of artillery material.[14]

Common shell for rifled guns.—The elongated common shells in use in the service are of various patterns. Some are made of cast-iron, others of cast-steel, and others, again, of forged steel; they have various calibres, from 4 to 12 inches, according to the guns with which they are employed. The bases and walls have to be sufficiently thick to resist the shock of the discharge from the gun, but must not be so thick as to reduce the cavity for holding the bursting charge within the limits which are required for a sufficient charge to burst the shell into a large number of fragments. The larger kinds are chiefly employed against such materials as earthworks; the smaller kinds against troops when they are protected by such cover as would prevent its penetration by the shot contained in shrapnell shell.

FIG. 8.



Section of Cast-iron Common Shell for Rifled Breech-loading Guns.

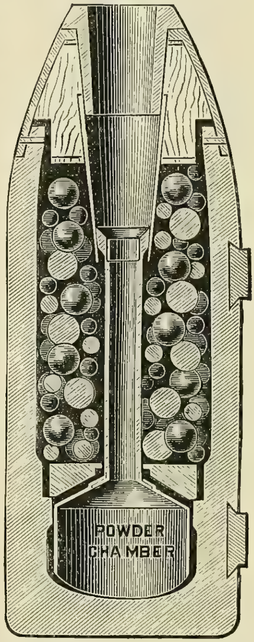
Various methods are employed for causing such large projectiles to be acted upon by the rifling of the guns. In some the desired rotation is obtained by coating the projectile with a covering of a softer metal; in some the soft covering is replaced by a single rim of soft metal, as copper, near the base; in some the projectile is furnished with studs or ribs to fit the grooves of the cylinder of the gun; in others, again, the rotation is obtained by means of a copper shoe, or 'sabôt,' fitted to the base.

The fragments into which these elongated shells burst are scattered in a different way from the fragments of spherical shells. In consequence of the revolving movement of these projectiles on their long axes, and the manner

in which the bursting charge is disposed along the cavity within, the fragments, as a rule, take a lateral direction in their flight; they are not scattered equally in all directions, as mostly happened with spherical common shells.

Shrapnell shell for rifled guns.—These are the most frequent sources of wounds inflicted by artillery projectiles. Two-thirds of the projectiles in the equipment of field and mountain guns belong to this class. The external appearance of a shrapnell shell is very similar to that of a common shell. Inside the shell is a number of bullets, and the bursting charge of powder is placed behind them. The bullets for 16, 9, and 7 pounder guns are of two sizes, the smaller ones being added to fill up the space. They are packed in melted rosin. The case of the shell is very thick behind the bursting charge, and there is an iron disc between this charge and the bullets. The front of the shell consists of an easily separable head, with a fuze at the apex when ready for use. The fuze is ignited by the flash of the gun or by percussion, and fires the primer, and the flash is communicated through the central tube to the bursting charge. The shell always points apex forward in its flight, as a small-arm rifle bullet does, owing to a similar arrangement as regards the rifling of the gun. When the bursting charge explodes, the head is blown off, and the shot, in addition to the onward movement which they had in common with the whole shell, now receive the increased velocity which is impressed on them by the explosion of the powder behind them. The bodies of the shells used with the guns mentioned consist of cast-iron; the studs for the grooves of the rifling are made of copper. These studs, on the bursting of the shell, become detached, and in warfare occasionally join in the infliction of very severe wounds. Shrapnell shells are used when the troops fired at are beyond the range of case-shot.

Fig. 9.

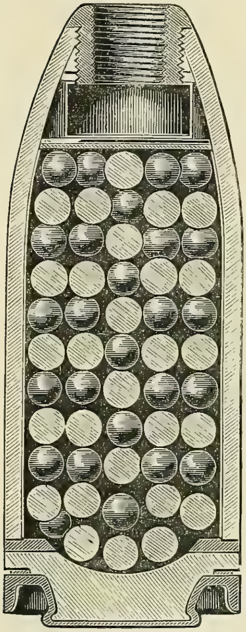


Section of 16 pr. Rifled Muzzle-loading Shrapnell Shell. Bursting Charge *behind*.

There are also in the service shrapnell shells in which the bursting charge is in front, instead of behind. In these the head is very firmly connected with the body of the projectile, while the base is very lightly attached to it. The head and base are made of cast-iron, while the body of the cylinder is composed of steel. When the charge of powder explodes, the head and body,

remaining together, pass over the bullets and fall to the ground, while the bullets are left to proceed onwards and become scattered. More bullets can be carried in these shells in proportion to their sizes, because there is no central tube or diaphragm in them; and the walls, being made of more resisting steel, can be made thinner than those of cast-iron. The cases of these projectiles are merely for holding and conveying the bullets; they are not intended to be broken into fragments for inflicting wounds. The bursting charges are consequently very reduced, and are only just sufficient to open the shell without interfering with the flight of the bullets. The pattern figured is one for a 15-pounder gun, and is filled with 100 mixed metal bullets 35 to the lb., 70 buckshot, and 10 cast-iron segments. There is a smaller shell of the same construction, which only weighs 7 lbs. 10 oz., and contains 100 mixed metal bullets 35 to the lb., 11 buckshot, and 10 cast-iron segments. In each instance the bursting charge only consists of half an ounce of gunpowder; just enough to open the shell and set the missiles free.

Fig. 10.



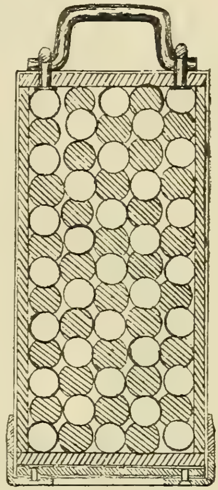
Section of 15 pr. Shrapnell Shell. Bursting Charge *in front.*

Case-shot for rifled guns.—Case-shot are fired from all descriptions of rifled ordnance. They are very similar in their general aspect to the case-shot which were fired from smooth-bore guns, excepting that they are more elongated in shape. They are not intended to take the rifling of the guns from which they are fired, and so are not, like other projectiles fired from rifled guns, provided with studs or other fittings for this purpose. If case-shot were made to rotate like common shell, the direct forward range of the bullets contained in them could not occur. The case used with the 8-inch breech-loading gun contains as many as 1415 8-oz. cast-iron shot packed in clay and sand; the relatively small 4-inch case shot shown in the figure contains 245 mixed metal 1-oz. bullets. The shot contained in case fired from the larger kinds of rifled ordnance have penetrating power up to 1000 yards and upwards; those contained in case discharged from field-guns are effective up to 300 yards.

Armstrong gun projectiles.—In the latter end of the year 1854, Sir William Armstrong submitted to the Minister at War a proposal for a rifled gun with projectiles on a new plan of construction. This gun was subsequently adopted among the armament

of the War Department, and there are now (1892) guns of six different calibres, from 6-pounders to 7-inch inclusive, on this principle in the service. Its peculiarities were the tough wrought-iron of which it was made, the rifling of its bore with 34 small grooves, and the fact of its being a breech-loader, with some special features in the mechanism for closing the breech.

FIG. 11.



Section of 4-in. Case-Shot for Rifled Breech-loading Guns.

The lead-coated projectiles for these guns include segment, common, and shrapnell shell, as well as case-shot. They afford points of interest to military surgeons, especially those known under the name of *segment shells.* They are made of cast-iron, thinly coated with an alloy of 19 parts of lead to 1 part of antimony; and being of somewhat larger diameter than the bore of the gun, the soft outer coat, when the gun is fired, is crushed into the grooves, and thus both rotation is given to the shell and at the same time windage prevented. The greatest recorded range obtained by the Armstrong projectiles has been 5¼ miles.

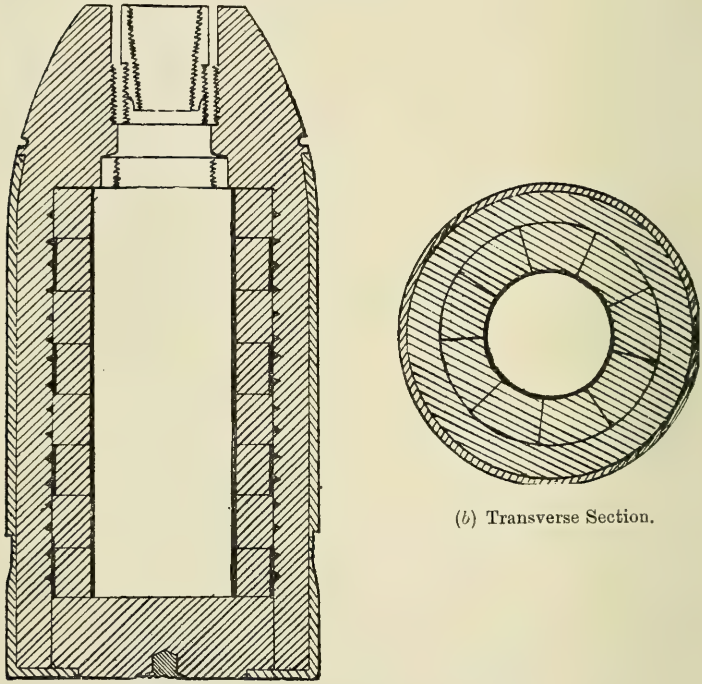
The segment projectiles can be used effectively as a solid shot, as a shrapnell shell, or as a canister shot (fig. 12). Within the thin cast-iron outer case there are a certain number (42) of wedge-shaped segments of iron; and these are built up in arched layers around a central cylindrical cavity. This cavity is designed to contain, when required, the bursting charge.

When used as a shot, this projectile requires no preparation; the arrangement of the wedge-shaped segments of iron is such that their compactness is uninjured by external pressure. The effect is much the same as pressure on the crown of an arch. Such projectiles have been fired through a mass of oak timber, 9 feet in thickness, without fracture.

When about to be used as a shell, and it is in this way that these projectiles are chiefly intended to be used, a bursting charge, if not already filled, and a concussion fuze are inserted. If the fuze be well timed and adjusted, the shell will burst within a few yards of the object; but if this should fail, it will burst from the effects of the concussion arrangement when it strikes the object, or grazes the ground near it. Some of these lead-coated shells were exploded in closed chambers where the pieces could be collected; and in one instance the following fragments were found—106 pieces of cast-iron, 99 pieces of lead, and 12 pieces of fuze, in all 217 pieces. At another time, in experimenting on

the effect of various methods of attaching the lead coating, some 12-pounder segment shells were burst in the same way, and the fragments collected. In one instance, 243 fragments ; in a second, 292 ; in a third, 310 pieces resulted. The object of these experiments was to ascertain the method most effective in producing the separation of the projectile into the greatest number of fragments, and they will also serve to give some idea of the number

Fig. 12.



(*a*) Longitudinal Section of Rifled Breech-loading Segment Shell.

(*b*) Transverse Section.

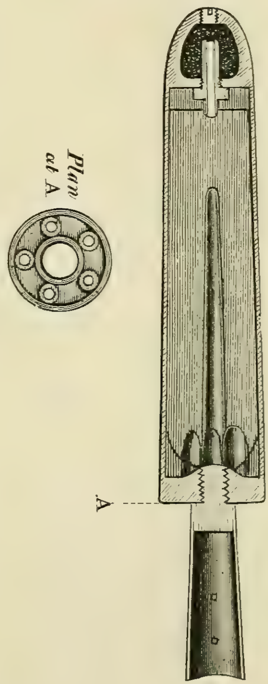
of wounds which might possibly result from the explosion of a single Armstrong shell among a body of troops. If one of the high explosives should be employed as the bursting charge, the range and force of the fragments as missiles will be immensely increased.

Whitworth guns and their projectiles.—The main difference between the Whitworth and all other systems of rifled guns is, that the weapons are rifled by surfaces, and not by indentations,

so that none of the force of the gunpowder is expended in changing the shape of the projectile by jamming it into the grooves. The form of the shot is such that the least possible friction occurs during its passage through the gun, and afterwards through the air, whence its initial velocity and length of flight are usually greater than those of a lead-coated projectile which is forced to take the rifling of the gun, when fired with a like charge, and under corresponding conditions. Whitworth 3-lb. bolts have been projected nearly 10,000 yards, or between 5 and 6 miles.

By the Whitworth method the barrel of the gun is rifled in a hexagonal, spiral form, and the projectiles are of the same hexagonal form externally that the bore of the gun is internally. Hence, neither the term 'balls,' nor that of 'cylindro-conoidal projectiles,' is applicable to them, and they have been usually referred to under the name of 'bolts.' They are required to fit the surfaces of the gun with the utmost mechanical precision, and they have not been adopted as service projectiles on account of the practical difficulties in the way of preserving their perfect coaptation after exposure in damp air, dust, and under other circumstances incidental to field service.

FIG. 13.



Congreve Rocket Shell.

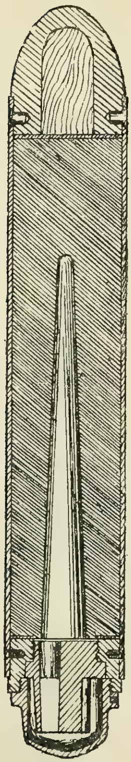
Miscellaneous projectiles.—Among the miscellaneous offensive weapons used in military operations, the following require mention, viz., war rockets, machine guns with their projectiles, and fougasses. A short description of their leading features follows.

War rockets.—Rockets in warfare used to partake both of the nature of *shot* and of *shell*, according to the manner in which they were used. Their use as shell projectiles has been discontinued. Instead of being discharged by an explosive force from guns, these weapons carry within themselves the means by which they are impelled onwards. A certain composition[15] within the case of the rocket constitutes the source of the impelling force. When this composition is ignited, its expansive energy exerts a pressure forwards, while the pressure at the rear of the rocket is neutralised by the flame and gases escaping into the air through apertures

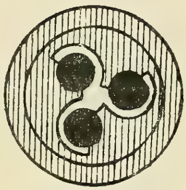
provided for the purpose. This forward pressure lasts so long as the combustion continues, and causes a constantly accelerated motion of the projectile, until the resistance of the air counterbalances its progressive force.

Rods were originally attached to the sides of war rockets, as they are in firework rockets, and as still employed in some service signal and life-saving rockets; but serious irregularities in their flight occasionally resulted from this arrangement. Sir William Congreve placed the rod in a receptacle, called the choke or neck, fixed in the central axis of the rocket (fig. 13), making provision at the same time, by several openings around it, for the escape of the gas behind when the composition was ignited. Notwithstanding this improved position of the rod, however, accidents frequently occurred in rocket practice.

Fig. 14.



Section of 24-pounder Hale War Rocket.



End of Cast-iron Tail-piece.

Rockets, when fired, are discharged out of portable *rocket machines*, or *troughs*, which rest on tripods. When directed against cavalry, they not only produce wounds by direct collision, but lead to many accidental injuries by the panic and disorder which they create among the horses. They were largely used for incendiary purposes at the siege of Sebastopol.

Hale war rocket.— In these rockets, which bear their inventor's name, the openings for the escape of the gas are placed obliquely to the long axis of the composition chamber, instead of being in the same line with it (fig. 14). The direction in which the gas is caused to escape from the projectile not only impels it forward, but at the same time imparts to it a rotatory motion round its long axis, corresponding with the spinning movement which is impressed on bullets by the rifling of fire-arms, and thus gives steadiness to its flight, without the aid of a rod at the base. The only rockets in use at present as war rockets in the British service are

24-pounder and 9-pounder rockets, and are constructed on the Hale system. They are only employed as shot rockets. A 24-pounder war rocket burns about ten seconds, and has an average range of 1500 yards; a 9-pounder rocket, burning eight seconds, has a similar average range, with a maximum of 2300 yards.

Star shells.—These projectiles answer a similar purpose when fired from rifled guns to carcasses from smooth-bore guns. Each shell contains a number of stars, which, on the shell bursting, are blown away on all sides, and emit a powerful white light. They are not designed for wounding purposes, only for illumination. Magnesium, chlorate of potash, and nitrate of baryta are some of the ingredients in the composition used with them.

Machine guns and their projectiles.—These are guns contrived for the purpose of discharging successive showers of comparatively small projectiles with great rapidity. As they stand upon their carriages they resemble the guns of light field-artillery; but as weapons, they belong essentially to rifled small arms. A volley from a machine gun in many respects resembles a discharge of grape or canister, whence the French name of the gun—*mitrailleuse*, from *mitraille*, grape; but a machine gun is not only capable of directing a more rapid fire, but also of securing greater precision of aim, within certain ranges, than can be attained with case-shot and grape discharged from field-guns. There is no loss of aim from recoil with machine guns when once they have been put in position.

Many military men on their first introduction believed that machine guns were destined to be largely employed in the field in all future wars; but the experience of the Franco-German war of 1870 tended to shake that conviction. It is doubtful whether they offer any such advantages as will induce combatants in the future to use them much in the open field; but there seems to be no doubt that they will be largely employed against opponents in the defence of bridges, entrenchments, and fortresses. It therefore is still a matter of interest to surgeons to have some knowledge of the nature of these guns, and of their power in respect to the infliction of wounds.

The machine guns in the British service at the present time are the Nordenfelt 1-inch, the Gatling, Gardner, Nordenfelt, and Maxim ·45-inch each, and the Gardner ·4-inch. The projectile of the large Nordenfelt is made of solid steel, with a sharply pointed conical apex, weighs over 6 ounces, and is fired by a charge of 625 grs. of powder; the bullets used with the ·45-inch machine guns are similar to those used with the Martini-Henry rifle; the ·4-inch Gardner has a special projectile, weighing 385 grs., and made of an alloy of 56 parts lead, 1 part tin, and 1 part antimony. It would be useless to attempt to describe the peculiarities of the

mechanism of the several guns above named in a work of this kind. The principles embodied in two machine guns, one of Belgian, the other of American invention, have been chiefly followed in Europe. The Belgian, known as the 'Montigny mitrailler,' from the name of its inventor, was furnished with 37 independent, externally hexagonal barrels, fitted together, and secured within a wrought-iron outer casing. The piece was fired by pulling a handle; the projectiles could be discharged in succession, slowly or rapidly, or they could be fired all at once in one second of time. The removal of the empty steel breech plate which had contained the cartridges, and the substitution of a full one, only occupied five seconds. Thus a continuous fire at the rate of ten discharges a minute could be kept up, equal to a delivery of 370 rifle-shots in a minute of time. The bullet used with this weapon was conical, about an inch in length, weighed 600 grains, and had a diameter of a little over half an inch (·534 in.). It was hardened, and had force enough at 60 yards from the gun to perforate 30 half-inch elm planks. When all the 37 bullets were fired together, they scattered in so comparatively small a degree, that at 800 yards the shower was limited to a space of about 12 feet in width by 10 feet in height; and at 1000 yards the further separation was only about two feet. Many experimental trials were made with this weapon at Woolwich and Shoeburyness, but technical defects were found in it which prevented its adoption in the British service, though it found favour in some other countries.

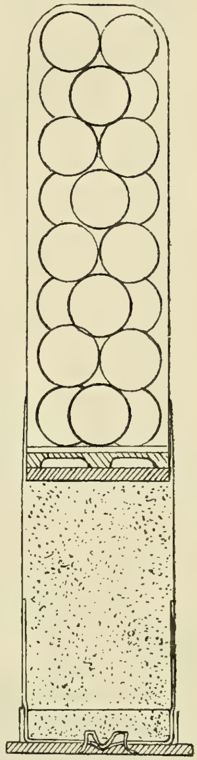
On the occasion of the Franco-German war the French brought into the field a number of 'mitrailleuses,' in batteries of eight mitrailleuses each, as part of their regular war armament. Each mitrailleuse had 25 barrels ranged in 5 rows in juxtaposition, and to these 25 cartridges were brought by the mechanism and were fired simultaneously. They discharged a heavy bullet nearly 2 oz. in weight. It was expected that great execution would be done by them, but they were overpowered by field-guns of other descriptions, and they failed to realise the anticipations that had been formed regarding them. They are now replaced by machine guns which more closely approach in principle the Gatling guns, and have the name of revolver-guns (*Canons-révolver*). They are each fitted with 5 barrels. The cartridge, which is over 2 lbs. in weight, contains 24 1-oz. bullets of hardened lead, and a charge of powder nearly 3 oz. in weight (90 grammes). (See fig. 15.)

The American machine gun, or Gatling battery, was introduced by its inventor in 1862. In 1866 the United States Government adopted this gun as part of their armament. It was exhibited, and attracted a good deal of notice, in the Paris Exhibition of 1867, and was afterwards tried in all the principal countries of

Europe. One of the machine guns which has been adopted by the War Department of the British army is on the Gatling principle.

Maxim automatic gun.—This is a single-barrel machine gun, which can be either fired on its wheeled carriage or supported on a tripod. By an ingenious mechanism, through which the recoil of the barrel at each discharge is turned to account, the empty cartridge is automatically removed, and a fresh one brought into position. Hence its designation of *automatic gun*.

Fig. 15.



Cartridge of the French Revolver Gun. (*After Delorme.*)

The following report respecting the work done by a ·45 Maxim automatic gun at the Easter manœuvres of 1892, by a detachment of the 3rd Vol. Batt. of the Royal West Kent Regiment, furnishes some idea of its capacity for inflicting wounds under suitable circumstances. The gun was drawn on its own carriage by one man over 1½ mile of rough ground. A position was taken up in a hollow, there being in front a rise in the ground over which the gun had to fire. The gun and gunners were screened by the ridge from observation at the butts, as well as from 45° to the right, to about 70° on the left, of the line of fire. The whole of the ground in front and on the flanks of the gun was invisible to the firer beyond 60 yards. The effect of the fire was reported by officers on the look-out on both flanks. The butts were distant 1200 yards from the gun. At this distance all the shots fell on the hostile position, striking the screens and ground on which they were placed. The effect of the fire was distinctly visible to the look-outs by the sand thrown up. The fire was by single shots, and also by rapid firing. In the latter case, bullets at the rate of 650 per minute were discharged, and caused a cloud of sand and dust to rise over the front of the butts. The gun and its detachment were so completely hidden in the hollow ground that the markers were unable to discover, by smoke or otherwise, whence the fire was coming.[16]

So far as surgeons are concerned in the treatment of wounds inflicted by machine guns, their introduction, like the change from muzzle-loading to breech-loading arms, has been calculated chiefly to lead to greater difficulties in field-hospital administration. No alteration of the characters of individual wounds has been caused

by such weapons, but instances of multiple wounds may be expected to be more numerous. The most serious question they give rise to is how far the surgical care and attention necessary for the increased number who are likely to be wounded by them within very short periods of time can be adequately provided.

Fougasses.—Fougasses are strong cases containing explosive materials, which are so disposed as to act as shallow subterraneous mines, and to wound men who may tread upon them. They are constructed on various plans, but all on the same principles, for the defence of places on land. Certain amounts of gunpowder or other explosive materials are placed in bottles or shells inside the outer case, which is then concealed a short distance below the surface of the ground, and such arrangements are made that the weight of a person walking over the spot suffices to cause the material to be exploded, and to effect the forcible projection of fragments of the case or of stones placed over it, and thus to wound some of the troops who are advancing to an attack. The Russians at Sebastopol employed water-tight boxes containing between 30 and 40 pounds of powder, and the ignition was caused by the action of sulphuric acid upon a mixture of chlorate of potash, sulphur, and other ingredients. The acid was contained in a glass tube concealed from sight by being lightly covered with earth, and the ignition was effected on the tube being crushed by the tread of a soldier. Some seconds occasionally elapsed before the explosion took place after the tube had been trodden upon, and General Airey appeared to owe the preservation of his life, on the occasion of the last armistice during the Crimean war, to this fact. His horse trod on one of these fougasses, but being in a canter at the time, was sufficiently advanced, when the explosion occurred, for the General to escape unhurt. The horse was, however, very near, for its tail was singed by the flame.

Fougasses serve military purposes, not only by means of the injuries directly inflicted by them, but also by their deterrent effects on assailants, owing to the uncertainty respecting their positions and numbers. Especially does this happen when assaults are made in the dark at night. In the month of June 1855, my friend Major Herbert, of the Welsh Fusiliers, had a very narrow escape from being destroyed by one of these infernal machines, as they were often called. He was in command of a large working party, and had to proceed across open ground in front of the trenches to a position known as 'the Quarries.' The men moved in line, and nearly the whole of the party must have gone close to the spot where a fougasse was hidden, without causing its explosion. It unfortunately happened, however, that a man of the 55th regiment who was carrying a stretcher, and who was one of the last men in the rear of the line, trod on the source of ignition, when the explosion immediately followed. The man was blown

to pieces, and the stretcher driven a long distance away, while five men were wounded. Major Herbert, who was not far from the place where the fougasse exploded, was struck by some of the earth scattered around by the explosion.

Fougasses were largely employed in the defence of places during the war of the rebellion in the United States, but they appear to have been usually designated 'torpedoes.' In Europe the name 'torpedoes' is generally restricted to the explosive machines placed in water, and designed for blowing up ships, and for purposes of coast defence. They are similar to fougasses in their nature and principles of action, but vary greatly in their forms, construction, and modes of ignition.

CHAPTER V

PORTABLE FIRE-ARMS AND THEIR PROJECTILES

Early history.—The first portable fire-arms, 'hand-cannon' and 'hand-guns,' were not invented until a century later than the larger kinds of gun or cannon. The hand-cannon was merely a small and light cannon carried by two men, and was fired from a rest fixed in the ground. The hand-gun was an improved hand-cannon, the tube being of greater length, and cast in brass. The tube was fixed on a straight stock of wood about three feet in length, and, like the cannon, was fired by a lighted match applied by the hand to some gunpowder placed in a small pan connected by a small opening—the touch-hole—with the charge in the interior of the gun. The projectiles used with it were probably, like those of the first cannon, made occasionally of stone, as well as of iron and lead. Hand-guns are said to have been in use in England as early as 1446. The hand-gun, like the arquebus which followed it, was fired from the front of the chest, and as its stock or butt was quite straight, it is obvious that the eye could not be brought into such a position in relation to the barrel of the gun as to enable an accurate aim to be taken at any given object.

The hand-gun was next improved by the introduction of a trigger, to cause the burning match to be brought quickly, and with precision, into contact with the powder in the pan. This contrivance was copied from the trigger of the cross-bow, and these improved hand-guns took the same name, 'arquebus,'[17] as had previously been applied to a kind of cross-bow which was fitted with a 'prodd,' or tube for the discharge of small stones and bullets, before the invention of gunpowder. The yeomen of the guard, when first formed in the year 1485, were armed one-half with bows and arrows, the other half with arquebuses. Among

troops the soldiers armed with the arquebus were designated arquebusiers. The arquebus was very similar to the 'matchlock,' such as may still be seen in use among some Eastern people.

The earliest English writer on injuries resulting from fire-arms is Thomas Gale. He was contemporary with Ambrose Paré, the earliest writer of note on the same subject in France. Gale published his 'Treatise of Wounds made with Gonneshot' in 1563. In his work he mentions that he served in the army, under Henry VIII., against France, in 1544. He probably remained with it till the end of the war in 1546. He also refers to his service with the English forces which assisted Philip II. of Spain, in defeating the French at St. Quentin, in 1557. At these periods the greater part of the British infantry were still armed with bows and arrows, halberds and pikes; only a small portion were armed with hand-guns or arquebuses.

About the year 1544, the musket, or musquet, a Spanish invention, was introduced into England. The musket was much longer and heavier than the arquebus, so that, when discharged, it had to be supported on a staff, fitted with a forked rest at the top, and with a ferule at the bottom to help in planting it in the ground. The muskets were matchlock fire-arms, and the soldiers who used them were called musqueteers. It is to be inferred from Gale's writings [18] that, in his time, stones were still in occasional use as shot, instead of leaden bullets, or pellets,[19] as Gale and the early English writers call them, with some of the above-named fire-arms.

'Snaphaunces,' which were portable arms discharged by the spark from a flint and steel, sometimes called 'flintlocks' or 'firelocks,' were invented to take the place of matchlocks in the time of Queen Elizabeth. The 'fusil,' a flintlock of about the same length and calibre as the musket, but considerably less in weight, was first made use of in England about the time of Charles II. Three of the regiments still known as fusiliers in the British army, were raised during this and the succeeding reign.[20]

It is quite evident, from a study of the fire-arms of early times, down to the time of the introduction of firelocks, that the arms were very unevenly bored, and that very little, if any, attempt was made to prevent escape of gas between the shot and the surface of the bore of the weapon by making the projectile fit the gun closely. Accuracy of aim was consequently unattainable. The force impressed on the projectile chiefly depended on the quantity of gunpowder used.

Muskets and their projectiles.—The observations embodied in Richard Wiseman's 'Treatise on Gunshot Wounds' were chiefly made by this admirable surgeon, so far as wounds among soldiers on shore were concerned, during a portion of the civil strife which led to so many battles in England between the years 1642

and 1650. At this time the shot used with the fire-arms carried by the troops had fixed weights and sizes. The common musket, still a matchlock, had 10 bullets to the pound, the arquebus 17 to the pound, the flintlock carbine 24 to the pound. Pistols were also in use with long barrels, and carrying shot about 20 to the pound.

The writer next to Wiseman of importance in England on gunshot wounds was the illustrious John Hunter. Sir E. Home, in his account of the life of his brother-in-law, John Hunter, mentions that he went with the army to Belle-Isle as a staff-surgeon; that he served, while the war continued, as senior surgeon on the staff, both in Belle-Isle and Portugal, till the year 1763; and that it was at this time he acquired his experience of gunshot wounds. Hunter himself mentions that he arranged his 'Treatise on the Blood, Inflammation, and Gunshot Wounds,' at Belle-Isle, after the reduction of the place.

The ammunition used by the troops at this time appears to have undergone no other change, so far as the projectiles were concerned, than a small amount of diminution in their weight. The gunpowder and musket had been improved in various ways. The flintlock was used universally instead of the matchlock. The infantry soldier was disencumbered of various articles of equipment which he had previously carried, and his arms were now confined to the smooth-bore musket of ·75 inch bore, weighing together with the bayonet a little over 12 lbs. The bullets were apparently of the same sizes as those in use at the beginning of the present century, viz., some nominally 14½ to the pound, varying from 480 to 488 grains, with a diameter of ·695 inch; and others weighing about 574 grains, with a diameter of ·745 inch. The charge of gunpowder was 6 drachms.

Leaden bullets were made in Hunter's time, and for many years afterwards,[21] by being cast in moulds. They were scarcely ever free from minute air-bubble spaces, owing to the lead being bulkier in the molten than in the solid state, and to the exterior becoming cooled before the substance within. From the fact just mentioned, and from impurities in the lead, it scarcely ever happened that bullets were of the same density throughout. This and various other causes, some of which will be noticed hereafter, caused the bullets discharged from muskets to be very irregular in their flight, their rate of velocity to be very low, and the distance to which they were capable of travelling very limited.

The same fire-arm and projectile continued in general use among the British troops, without any improvement of note, during the Peninsular campaigns from 1808 to 1814, in the campaign of 1815, during the American war between 1812 and 1814, and in the numerous battles in which British troops were engaged in the East Indies. The smooth-bore musket in use during this

period, commonly known among soldiers under the name of 'Brown Bess,' was the fire-arm of the infantry during the period at which Guthrie, Hennen, Thompson, and many of the most eminent writers on the subject of gunshot injuries practised and wrote.

In the year 1839, the flintlocks of the muskets then in use in the British army were altered into percussion locks. No difference was made either in the projectile or in the charge of powder at this time.

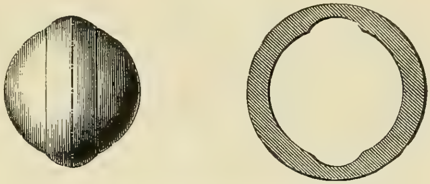
In 1842, a new percussion musket was adopted. The changes made had reference chiefly to the mechanism of the weapon; the size of the bore remained as before, viz., ·753 inch. This large diameter of the barrel, larger than that of the muskets in the hands of the soldiers of all the chief Continental armies, gave an advantage to the British soldier; for while the large musket bullet of the British weapon could not be fired out of any of the Continental muskets, any of the Continental ammunition could be used with the British musket in case of need. This musket was 'sighted' for 150 yards.

Double-shotted muskets.—When smooth-bore weapons were in use, it was an accident of frequent occurrence for two or more charges to be fired off at once, owing to the pieces not having been previously fired, either from carelessness or from nervousness on the part of soldiers; but double-shotting of muskets was also occasionally ordered by the military authorities under special circumstances. According to the French official reports of the Crimean war, quoted by Dr. Chenu, each infantry soldier in the field was furnished with ten spare bullets, carried loose, in addition to his 54 rounds of cartridges. The loose bullets were ordered to be employed in certain cases of fire at short distances, one being added at each discharge of the weapon. There were thus two bullets to one charge of powder.

Rifled muskets and their projectiles.—The invention of spiral rifling of portable fire-arms occurred about the year 1520, but was not then turned to practical account in the military service. There was considerable difficulty and much loss of time in loading the early kinds of rifled muskets, and these inconveniences were, no doubt, the causes which prevented their adoption for army purposes. It was only at the commencement of the present century that a rifled musket was placed in the hands of British troops. In the year 1800, the 95th regiment, afterwards named the Rifle Brigade, was armed with a weapon known by the name of 'Baker's rifle.' It was fitted with seven slightly twisted grooves, and could only be loaded with great difficulty. The projectile was a spherical leaden ball, and there were 20 of them to the pound weight. In 1836, a two-grooved rifle, called the 'Brunswick rifle,' was issued to the same regiment instead of the

Baker rifle. The two grooves made one turn in the length of the barrel. The bullet, a round one, was provided, as shown in the illustration (fig. 16), with a projecting belt, which had to be placed in the terminations of the two grooves, at the mouth of the musket, in the act of loading. The weight of the bullet was 557 grains; its diameter, ·696 inch; the charge of powder, $2\frac{1}{2}$ drachms. The aim with this rifle was said to be accurate up to about 400 yards.

FIG. 16.

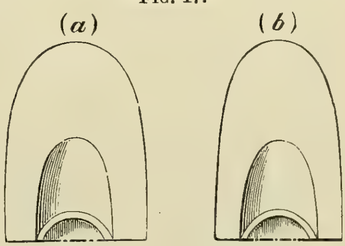


Brunswick Rifle Bullet, and Muzzle.

The imperfection and comparative inefficiency of the 7-grooved rifle previously in use may be readily understood when it is mentioned that for loading it the soldier had at one time a mallet issued to him for driving down the bullet, which was a little larger than the bore of the rifle. Only one quarter of a turn could be given to the grooves in this rifle, owing to the danger of 'stripping' while forcing the ball down the barrel. With the belted ball of the two-grooved rifle a great part of the labour of inserting the bullet was got rid of, and one whole turn was given to the rifling. When this change was made, a soldier of the rifle corps was able to strike an object at 300 yards with more certainty than he had been able to do previously at 150 yards.

Minié rifle.—In 1851, a rifled musket and special projectile, invented by Captain Minié, a French officer, were issued to a part of the troops of the British army. This weapon took the place of the smooth-bore percussion musket. The essential features of the bullet used with this new fire-arm were a change in its form, and the addition of a 'culot,' or small hemispherical iron cup, at its base. By means of the culot the lead of the bullet in the act of discharge was expanded and forced into the grooves of the rifle. The gas evolved in the explosion of the gunpowder was prevented from escaping by the side of the bullet, which completely blocked the barrel, and thus a longer range and greater accuracy of flight were ensured. The bullet used with the English Minié rifle was a very large one; it was 680 grains in weight, and its diameter was ·69 inch. The form (fig. 17) was at first (*a*) conoidal, but was subsequently changed to (*b*) cylindro-conoidal. The charge of powder was two drachms and a half. The weapon was sighted

FIG. 17.



Minié Rifle Bullet.

for ranges of from 100 to 1000 yards, and its point-blank range was 177 yards. This was the weapon with which a large number of the British troops were armed when they landed in the Crimea in 1854, and that was used by them at the battles of Alma and Inkerman. In consequence of the iron cup being occasionally driven through the bullet, leaving the latter a cylinder of lead inside the fire-arm, a boxwood plug was substituted for it, and to give additional ease in loading, the diameter was reduced from ·690 to ·675 inch.

Enfield rifle.—In the year 1855, while the Russian war was in progress, a lighter and still more effective weapon was issued to the British army, instead of the Minié rifle of 1851, and the percussion muskets of 1842, which were still in use in some regiments. This was the Enfield rifle of ·577 inch bore. It remained the weapon of the British infantry until the year 1871, when it was replaced by an entirely new rifle; but several important changes and improvements were made in it during this interval. The bullet first used with the Enfield rifle was of a cylindro-conoidal form, with a hollow base without any cup or plug. Its weight was 530 grains, and its diameter ·568 inch. An iron cup was afterwards placed within the cavity of the base, similar to the cup in the Minié rifle bullet, and this was again changed for a boxwood plug. Short Enfield rifles were supplied to the Rifle Brigade and 60th Rifles, which were 6 inches less in the length of the barrel than those issued to the troops in general. Steps were taken to ensure a perfect quality of lead for the Enfield rifle bullets, because even a slight impurity was found to affect their weight, evenness of consistence, and expansion. The new bullets were pressed into shape by machinery from rods of pure lead, and there was now found to be scarcely any perceptible difference in their respective weights. Their even density gave them greatly increased efficiency when they were compared with bullets which had been cast in moulds.

Fig. 18.

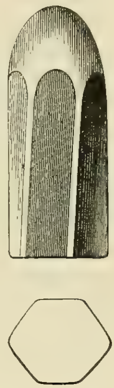
(a) Enfield Rifle Bullet, and (b) its Base with the Boxwood Plug.

A change in the shape of the Enfield bullet was made in 1859, during the Sepoy mutiny, in consequence of complaints coming from India of difficulties in loading the rifle. It was slightly decreased in diameter, and increased in length. The diameter was fixed at ·55 inch, and the length 1·09 inch; the weight, with the plug, continued to be 530 grains. (Fig. 18.)

Whitworth rifle bullets.—At the time of the Crimean war, Mr. Whitworth, the well-known mechanist, advocated the use of rifles constructed on principles different from those of the Minié or Enfield rifles. The peculiarity of the Whitworth rifle, like the

Whitworth gun before alluded to, consisted in obtaining the rifling by surfaces, not by grooves, as in the other systems. The interior of the barrel was hexagonal, with one turn in 20 inches, and the bore was only ·45 inch in diameter. The bullets were of two kinds: hexagonal, corresponding with the interior of the barrel; and cylindrical, with a hollow base, in which last case they were forced during their discharge to take the shape of the interior of the barrel. The cylindrical bullets had therefore to be of comparatively soft metal; but the hexagonal bullets, being independent of expansion, could have any degree of hardness imparted to them, and were usually made of an alloy of lead and tin. This caused the Whitworth hexagonal projectile to differ from all other rifle projectiles in use at the time. (Fig. 18.)

FIG. 19.



Whitworth's Hexagonal Bullet, and section of bore of rifle.

In 1864, three rifle regiments were armed with Whitworth rifles, and other regiments were supplied with 100 Whitworth rifles each, to be tried in different climates. The reports were considered most satisfactory as to power and accuracy; but certain military objections were made to them, which need not be mentioned here. They are now no longer in use as military arms.

Breech-loading fire-arms.—The fire-arms just referred to, both plain and rifled, were loaded at the muzzle; the change to breech-loaders has now to be noticed.

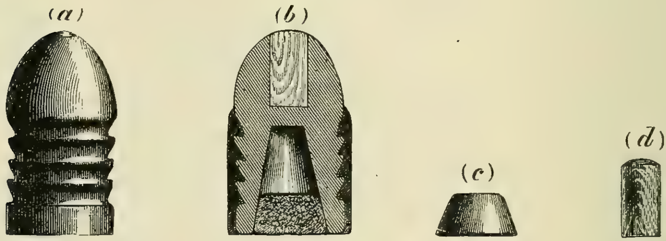
The first breech-loading small arms used in the British service were carbines, issued to a few cavalry regiments in 1858. In 1862, the Government distributed 1000 breech-loading *muskets* among several regiments for practical trial. The fighting advantages of these weapons were their rapidity of fire and capacity for easy loading in any position of the soldier; among their chief disadvantages were a difficulty in entirely preventing escape of gas at the breech, and the necessity for a special cartridge, such weapons not admitting of discharge with loose powder like the muzzle-loading fire-arms previously in use.

The subject was submitted for consideration to a special committee in 1864, and the result of their deliberations and trials was that arming the infantry with breech-loaders was decided upon; the only question remaining being that of the mechanical form of breech-loading which should be adopted. The proved advantages to the Prussians of the use of breech-loading fire-arms in the war of 1866 against the Austrians hastened the settlement of this point. It was found that, by a system devised by Mr. Snider, Enfield rifles could be converted into serviceable breech-loaders, and the work of transformation was shortly afterwards effected.

Snider converted Enfield rifle.—The projectile for these altered rifles was changed in some few respects. The weight was reduced to 480 grains, complete with its plugs. It was 1·04 inch in length. Its hollow base carried a baked clay plug; it had four saw-shaped cannelures round the outer circumference near the base, which served to retain a thin coating of wax; and it also had a wooden plug in the head (fig. 20). The introduction of the last-named plug afforded greater length to the projectile without adding greatly to its weight, at the same time that it disposed the weight of the lead away from the axis of rotation, after the manner of a fly-wheel. From twelve to eighteen shots could be fired in a minute with the Snider converted Enfield rifle. The bullet was expanded by means of the hollow in its base, and of the baked clay plug. The clay plug took the place of the iron cup and boxwood plug which had been used with the Minié and Enfield rifle bullets.

In March 1869 it was settled that the wooden plug in the

FIG. 20.



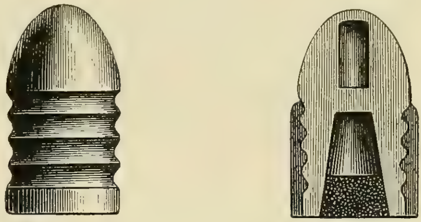
Boxer Ammunition for Snider converted Enfield Rifle, (*a*) Elevation, (*b*) Section, (*c*) Clay Plug, (*d*) Wood Plug.

head of the bullet should be removed, the cavity in the apex being closed by spinning the lead over it. This bullet had therefore both its base and front hollowed out. This was the last form of projectile which was used with the Enfield rifle (fig. 21). It was said that this bullet had all the advantages of accuracy possessed by the previous Enfield bullet, at the same time that it was superior to it as a weapon of destruction; the wounds by this hollow-headed bullet being much more severe and extensive than any inflicted by a solid-headed bullet of the same size.

Previous investigations had tended to show that the calibre, twist, and form of rifling of the Enfield rifle, were not the most favourable for accurate shooting; and it was therefore not unknown that the Enfield would, in time, have to give place to a new breech-loading weapon of smaller calibre, notwithstanding the great outlay which would be involved in the change. A

reduction of size in the bullet was necessary, that soldiers might carry the increased quantity of ammunition required to meet the capacity for rapid fire of breech-loading arms, and to put the English on an equality in this respect with other nations.

Fig. 21.



Enfield Rifle Bullet with Hollow Front and Base.

Martini-Henry rifle.—In consequence of the attention directed to the improvement of rifled fire-arms, many means by which the power and accuracy of the converted Enfield rifles could be increased had become apparent. In order to get combined in one rifle, as far as possible, all that had been discovered in these respects, the Government, in October 1866, offered a prize for a new arm fulfilling certain conditions. The competition trials took place in 1868. Subsequently, in 1871, a new weapon was formed out of two of the competing rifles, the Henry rifle and the Martini rifle, by uniting the barrel of the former to the breech of the latter. This combination constituted the rifle since known as the 'Martini-Henry rifle.' It was in this same year that the Germans changed the needle-gun for the Mauser rifle, and not long afterwards the French adopted the Gras in place of the Chassepôt rifle.

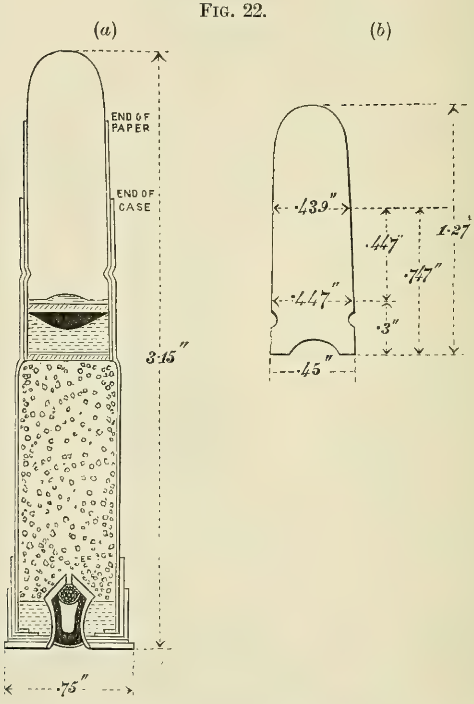
The bullet used with the Martini-Henry rifle is not made of pure lead, as that of the Enfield was, but of lead hardened with tin, in the proportion of 1 lb. of tin to 12 lbs. of lead. It is cylindro-conoidal, solid, compressed, is 1·27 inch in length, and has a slight cavity at the base, which is ·450 inch in diameter. The bullet tapers upwards from the base to its smallest diameter (fig. 22). There is one shallow cannelure near the base, into which the metal cartridge case is secured. Its weight was at first 480 grains, but in 1875 it was reduced to 410 grains. The original charge of powder has also been lessened from 85 to 80 grains. There is a paper cap over the bullet lightly smeared with bees-wax. A rapidity of fire without aim, amounting to 25 shots in a minute, was attained with this weapon. As great an accuracy of aim could be got with it at 1000 yards as with the Enfield at 600 yards.

The greatest range of fire obtainable with the Martini-Henry rifle by elevating the rifle at a considerable angle (28° 15′) is 3685 yards. The bullet starts from the muzzle of the rifle under favourable conditions with a forward velocity of 1350 feet in a second of time, and at a distance of 1000 yards still preserves a velocity of 672 feet in a second. It travels over the 1000 yards in a little more than three seconds. If brought into collision with an object

close to the muzzle, its striking force would be equivalent to 1940 foot-pounds;[22] at 500 yards it would strike with a force of 1309 foot-pounds; at 1000 yards it would still possess energy equal to 480 foot-pounds. Its point-blank range as regards infantry is between 400 and 500 yards, the greatest height of its trajectory at 400 yards being only 5 feet. Its initial velocity of rotation is 736 revolutions in a second.

If the bullet should start at the reduced muzzle velocity of 1315 foot-seconds, probably its average rate, then at a distance of

FIG. 22.



(a) Section of Ball Cartridge of Martini-Henry Rifle. (b) Bullet of ditto.

500 yards it would have a velocity of 869 foot-seconds, and at 1000 yards a velocity of 664 foot-seconds. Its energy at the muzzle of the rifle would be equivalent to a force of 1841 foot-pounds, and at a distance of 1000 yards would still have a striking force equal to a pressure of 469 foot-pounds.

The penetrative power of the hardened lead bullet fired from the Martini-Henry rifle is very great. When fired, at 25 yards off, into half-inch elm planks placed one inch apart, the average penetration was through fourteen planks and a half; from the same distance the bullet of the Enfield rifle penetrated only

eight planks and a half. When fired against an iron plate one-eighth of an inch thick, the Martini-Henry bullet perforated it at 600 yards; the Enfield failed to do so at 300 yards. The Martini-Henry penetrated a mantlet made of four thicknesses of 3-inch rope at 350 yards, while the Snider Enfield could not penetrate it at 50 yards. Some comparative trials were made on the carcase of a horse with the hardened Martini-Henry and soft lead bullets, and, according to the report of a veterinary surgeon who was present, the most severe fractures were those produced by the Martini-Henry projectiles.

Recent changes in military rifles.—Several alterations in military rifles, destined to exert an important influence on their wounding results, have occurred since the Martini-Henry weapon, which has just been described, was introduced. Their calibres have been still further reduced, their projectiles have been encased in hard resisting envelopes, and means have been added for rapidly replacing the charges which have been fired by others from magazines attached to the weapons. In nearly all armies changes have also been made in the kind of explosive by which the projectiles are propelled. Of these several alterations, the reduction in size of the bore of the rifle, with its necessary accompaniment, the diminution in diameter and weight of the projectile, is of all the changes the one which entails consequences that present the most points of interest to military surgeons.

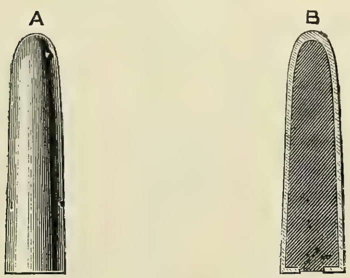
A rifle discharging a bullet of only 0·4 inch had been adopted in Switzerland as far back as 1863, and in that country, as well as in others, rifles of still less calibre had been under trial. In the year 1885 a rifle was approved for the British service with a calibre of 0·402 inch, instead of the 0·450 inch of the Martini-Henry. This was called the Martini Enfield, and a large supply was manufactured; but before the weapon was issued to the army generally, the question of a still further reduction of the bore was forced prominently into notice. In consequence, an extended series of trials was carried out, and eventually a still smaller bore was adopted, viz., one of 0·303 inch. Concurrently with this alteration, the addition of a 'magazine,' or metal compartment for containing a reserve of cartridges, was settled. This new rifle is officially described as the Lee-Metford rifle, from the names of the respective inventors of the breech action of the weapon, and of the system of rifling, but is often spoken of as the small-bore magazine rifle.

The Lee-Metford or magazine rifle.—There are two forms of this rifle, distinguished as Mark I. and Mark II., but the mechanical differences between them are of no importance to surgeons. Each form has its magazine: that of Mark I. being of a size and shape to hold eight cartridges in a single column; while the Mark II. pattern is broader, and holds ten cartridges in two columns, side

by side. Each kind of magazine can be easily detached, and easily replaced by another of the same description, when required. The rifle can be used as a single loader or as a repeating rifle; for ordinary occasions it would doubtless be used as a single loader, the magazine reserve being kept for occasions of special urgency. The grooves of the rifling, seven in number, have a sharp twist, viz., one complete turn in ten inches, so that a very rapid rotation is given to the bullet. Its stability, notwithstanding its narrow diameter and length, is thus ensured. On the other hand, the great amount of friction between the bullet and the barrel in the act of following the twist of the rifling gives rise to very considerable heating.

The projectile is a compound cylindro-conoidal bullet, consisting of an inner portion, or core, of lead hardened by the addition of 2 per cent. of antimony, and of an outer cover of hard metal, or mantle of cupro-nickel, an alloy consisting of 80 per cent. of copper and 20 per cent. of nickel. The hardness of this cover serves to prevent 'stripping' as the bullet is forced through the rifling, and increases the penetrative power of the projectile. In consequence of the amount of heat developed by the ignition of the powder, and the friction between the bullet and the barrel, were the leaden core and the cover of the bullet not closely connected, the core might become softened and driven through the front of the cover of the projectile. Instances occurred in the earlier experimental patterns in which the lead was forced completely through the front of the envelope. Hence this portion of the envelope is usually made thicker and more resisting than the hinder portion (see fig. 23, B). As before mentioned, the diameter of the bullet is about 0·3 inch; its length is 1·2 inch. There are no cannelures upon the bullet used with the black powder ammunition; its surface is perfectly smooth and polished, so that it meets with the least possible resistance in its flight through the air. There is one slight cannelure on the bullet used with the cordite ammunition. The trajectory of the bullet is very low; when the fixed sight only is used, according to regulation, a bullet fired from the rifle would be capable of striking such an object as a man standing in front up to 500 yards, if the feet be aimed at; but taking ricochet and badly aimed shots into account, men standing 200 or 300 yards

FIG. 23.

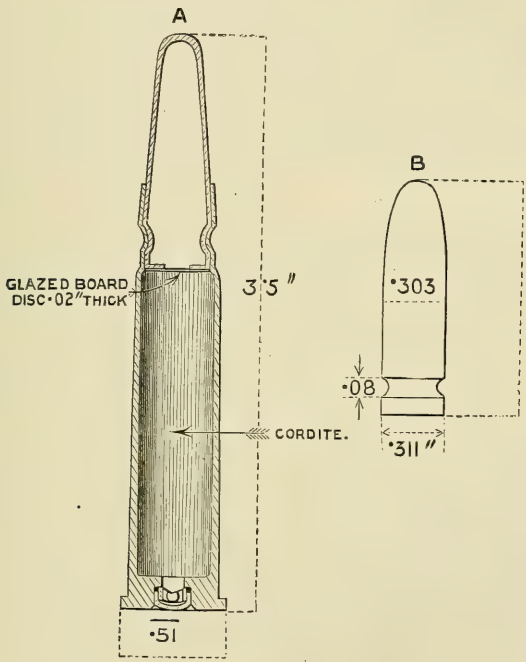


(a) Bullet of Magazine Rifle used with Black Powder Ammunition. (b) Section of ditto.

farther off would be liable to be struck. The rifle has two sets of sights—one consisting of the usual back and fore sights; and the other described as 'long-range' sights. The back sight is graduated up to 1800 yards; the long-range sights, for extreme ranges, are placed on the left of the weapon, and are provided for ranges from 1600 to 2900 yards.

Two kinds of ammunition have been prepared for these weapons, viz., ammunition with black gunpowder, and smokeless

FIG. 24.



(*a*) Section of Ball Cartridge of Magazine Rifle with Cordite Ammunition.
(*b*) Bullet of ditto.

powder ammunition. In the former the cartridge contains a charge of 70 grains of compressed gunpowder; in the latter, 30 grains of cordite, in the form of small rods, as before mentioned, of which there are from 57 to 60 in number. The only difference in the bullets used with the two kinds is that while in the black powder ammunition, as before named, the envelope of the bullet is smooth from apex to base, in the smokeless powder ammunition it has a shallow groove or cannelure one-tenth of an inch above the

level of the base. This groove, which itself is nearly one-tenth of an inch in width, is filled up with beeswax, so that the smoothness of the surface of the bullet is not interfered with. The bullet is secured in the cartridge by three indents of the metal case into this cannelure.

When the ammunition with black powder is used, the bullet starts from the muzzle with a velocity of 1850 feet in a second, and its weight being only 215 grains, its striking force at the muzzle would be equivalent to 1632 foot-pounds; with the cordite ammunition its initial velocity is about 2000 feet in a second. If 2000 feet precisely, its total energy or capacity for overcoming resistance would be equivalent to a pressure of 1907 foot-pounds; if 2016 feet, its total energy would be equal to a pressure of 1938, or practically the same as the heavier Martini-Henry bullet. The form of the bullet, its smooth surface, its small sectional area, the rapidity of its rotation by which it is kept spinning on its long axis apex forwards, all combine to favour the maintenance of a high rate of velocity in the bullet over a very long range.

Pistols.—These comprehend the lightest kind of fire-arms employed in war, being made so that they can be held and fired by one hand only. The bullets discharged from them have hitherto been the lightest and smallest-sized projectiles fired *singly* for military purposes, but though differing in form, the projectiles of the Lee-Metford rifle now approximate to some of them in respect to weight. 'Carbines' hold an intermediate place between pistols and rifles.

Various kinds of pistols may be met with in the hands of army officers, but there are only three patterns for which ammunition is manufactured in the Royal Laboratory. These are all breech-loading, and all revolver pistols. They are technically known as the Enfield revolver, the Webley revolver, and the Adams revolver pistols. Some muzzle-loading pistols are still used in colonial service, but when required for issue, are obtained by purchase from the gunsmiths.

The Enfield revolver pistol is identical in the diameter of its bore, and in the form and twist of its rifling, with the Martini-Henry rifle. The cylinder contains six chambers for cartridges, and it is loaded in the ordinary way. The act of pulling the trigger, cocks the pistol and fires it, and on releasing the trigger it rebounds to half-cock. The bullet is made of 12 parts of lead and 1 part of tin, has a clay plug at the base, and is grooved near the base by 3 cannelures, which are filled with beeswax for lubrication. Its weight without the clay plug is 265 grains. In the earlier patterns the diameter of the bullet was 0·455 inch; in the later patterns it has been increased to 0·477 inch. The charge of powder is 18 grains. The length of

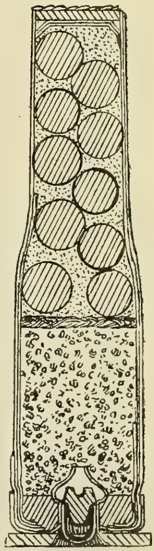
the bullet is nearly 1 inch (·897 inch), the length of the cartridge 1·47 inch.

The Webley revolver closely resembles the foregoing, chiefly differing in the mechanism of the breech fastenings and their mode of action. The bullet is slightly longer, viz., ·945 inch, and it also differs in having only a hollow at the base, without a clay plug. The weight and composition of the bullet and charge of powder are the same as in the Enfield revolver bullet. It has a muzzle velocity of about 700 foot-seconds.

The bullet of the Adams revolver is slightly less in volume and weight than the projectiles of the two pistols just named. It differs from them also in being made of pure lead. The diameter of the barrel of the pistol is 0·434 inch, and that of the bullet 0·455 inch. The length of the bullet is 0·765 inch, and its weight 225 grains. It is fired by a charge of 13 grains of powder.

The gunpowder used with all these pistols is of a specially fine quick-firing quality, so as to ensure the whole of the powder in each relatively small charge being at once ignited.

FIG. 25.



Section of Buckshot Cartridge for Martini-Henry Rifle and Carbine.

There was lately, and probably still is, a smooth-bore pistol in use in India, the East India 8-inch pistol, used by some of the native cavalry, having a large bullet, 0·6 inch in diameter, weighing 350 grains; but smooth-bore ammunition for pistols is no longer issued to European troops.

Buckshot.—These are the smallest bullets employed in the British service. Three kinds are used—two being used as ammunition for small arms, one constituting part of the contents of certain shells.

The buckshot used as small-arm ammunition were at first made wholly of lead. They were made up into cartridges for use with the Snider rifle and carbine, and with all rifled weapons having barrels of a diameter of ·577 inch. Each cartridge contained 13 buckshot, the weight of the whole being 520 grains. The weights of the individual buckshot varied from 30 to 33 grains each. They have been issued for convict-guard service and for use in wars with uncivilised people. The shape of the front is like that of a ball cartridge, but the buckshot occupy the place of a bullet.

A cartridge with a front of different shape containing buckshot has also been adapted to the bore of the Martini-Henry ammunition, and can be fired either from the Martini-Henry rifle or carbine. It contains 11 buckshot, packed in bone dust. Like the Martini-Henry rifle bullet, they are hardened by being made of 1 part of tin to 12

parts of lead. Their weight, like the weight of those used in the Snider cartridge, is 220 to the pound.

Buckshot of rather larger size were formerly used with smooth-bore carbines. Each cartridge for this arm contained 7 buckshot, the weight of the whole being 378 grains. The several buckshot individually varied in weight from 52 to 56 grains. The same-sized buckshot, but 12 in number, were also prepared for use with smooth-bore muskets.

The buckshot prepared for use in the diaphragm shrapnell shells are hardened by using a certain proportion of antimony with the lead. Their weight individually is a little under a drachm, varying between 55 and 58 grains.

Large numbers of buckshot cartridges were manufactured for use in the last Ashanti war on the Gold Coast. The cartridges were of two kinds—one for the muzzle-loading Enfield rifles, with which some of the native allies were armed; the other for breech-loading rifles in the hands of the British troops. Sixteen buckshot were enclosed in each cartridge.

Fire-arms and Projectiles of Foreign Armies.

The description previously given of the *large guns* and projectiles of the British service renders unnecessary any description of the corresponding guns and projectiles of foreign armies. The differences that exist between them are chiefly in mechanical details that rather concern artillerists than surgeons; it is mainly the nature of the explosives that are employed as bursting charges in the hollow projectiles fired from them which affect the numbers and severity of the injuries they are likely to produce, and on this point little reliable information is obtainable.

The weights and other features of the small projectiles used with the *portable arms* of foreign armies may, however, be referred to with advantage, more especially as, in case of England being engaged in a Continental war, these would be the sources of the greatest numbers of wounds which would come under the care of British surgeons.

As before mentioned, nearly all the leading Powers of the world have now magazine rifles with small bores in use in their armies.

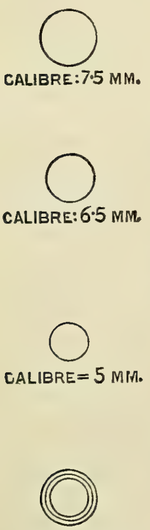
The particulars in the following table show the sizes, weights, initial velocities, and some other features of the projectiles used with the magazine rifles in the principal armies of Europe.

Leading Features of the Principal Military Small-Bore Magazine Rifles and their Projectiles.

Army.	Weight of Rifle.	Calibre.	Weight of Bullet.	Length of Bullet.	Materials of Bullet and Envelope.	Charge.	Muzzle Velocity.	Sighted to	Rounds in Magazine.	Remarks, Pattern and Date.
	Lbs.	Inch.	Grains.	Inch.			Foot-Secs.			
British . .	9·4	0·303	215	1·26	Hard lead and cupro-nickel	Pellet black powder, 70 grains Cordite, smokeless powder, 30·5 grains	1850 2000	2900 yards	8	Lee-Metford, 1890
French . .	9·21	0·3149	231·5	1·22	Hard lead and maillechort [23]	Smokeless powder, 43·2 grains	2073	2187 yards	8	Lebel, 1886
Austrian . .	9·7	0·3149	243·8	1·25	Hard lead and steel	Smokeless powder, 42·43 grains	1706	2500 paces	5	Mannlicher, 1888–90
German . .	8·37	0·3111	226·9	1·26	Hard lead and cupro-nickel	Smokeless powder, 42·43 grains	2034	2241 yards	5	Mausĕr, 1888
Portuguese .	9·6	0·323	246·8	1·28	Hard lead and steel	?	1672	?	?	Kropatschek, 1886
Russian . .	9·37	0·3	214	1·20	Hard lead and white metal	Smokeless powder, 30·5 grains	2034	2900 yards	5	Kapit Mosin, 1891
Roumanian .	8·48	0·2559	159·2	1·23	Hard lead [24] and steel, plated	Smokeless powder, 37·8 grains	2295	3000 yards	5	Mannlicher, Roumanian, 1892
Italian . .	8·2	0·2559	162	1·2	Lead and white metal	Smokeless powder, 30·5 grains	2296·6	2900 yards	5	Mannlicher, 1891
Belgian . .	8·6	0·3012	219·1	1·2	Soft lead and cupro-nickel	Smokeless powder, 47 grains	2001	2187 yards	5	Mauser, 1889
Swiss . . .	9·48	0·2952	211·5	1·13	Hard lead, with steel point and paper jacket	Smokeless powder, 30 grains	1968	2187 yards	12	Schmidt Rubin, 1889
Danish . .	9·37	0·3149	238·1	1·18	Soft lead and cupro-nickel	Smokeless powder, 33·9 grains	1968	1531 yards	5	Krag Jörgensen, 1889
Spanish . .	8·89	0·3012	216	1·21	Hard lead and white metal	Smokeless powder, 37 grains	2139	2241 yards	5	Mauser, 1890
Turkish . .	8·6	0·3031	219·1	1·23	Lead and maillechort	Smokeless powder, 47 grains	2065	2187 yards	5	Mauser, Belgian, 1889

It does not appear that the decrease which has taken place of late years in the size of calibre of modern rifles can yet be regarded as final. Some military officers, as well as others who have studied the subject, advocate a still further reduction. General R. Wille, of the Prussian army, has recommended a diminution of the calibres of rifles to 6 mm. (0·2362 inch), and Professor Hebler, in Switzerland, has suggested that the calibre should be reduced to 5 mm. (0·1968 inch) as the best lowest limit. It is said that barrels of this calibre can be manufactured without any very special technical difficulty. Experiments which have been made near Vienna before the Austrian Technical Military Committee have, according to non-official statements, proved that rifles of 5 mm. calibre possess some remarkable advantages over those of somewhat larger calibres, such as from 6 mm. to 8 mm. calibres. The weapons with the smaller bores gave the most favourable results as regards flatness of trajectory, recoil, and penetrative power, while the diminished size and weight of the cartridge enabled a considerably larger number of rounds of ammunition to be carried by the soldiers. Should future experience confirm the alleged practical value for military purposes of rifles with such contracted bores, and should they be adopted as infantry weapons by any leading European Power, it would probably lead to their adoption by other Powers, and the surgical effects of the slender projectiles that would be fired from them would then have to be especially studied. No narrower rifle bullet is likely to be brought under the consideration of surgeons, for it is laid down by musketry experts that 5 mm. is the lowest limit of size theoretically or practically admissible for the bore of a rifled weapon. Even in simple flesh wounds a projectile of that size, small as it is, would probably be sufficient to disable a man for a few weeks. Up to the present time, however, the 6·5 mm. rifle projectile adopted in the Italian and Roumanian armies, which has a diameter of rather more than a quarter of an English inch (0·2559 inch), is the smallest in width of any rifle bullet employed for military purposes.[25] The illustrations in fig. 26 show the relative sizes of the bore of the 6·5 mm. rifle of the Italian army, and of the 0·303 inch (7·5 mm.) Lee-Metford rifle of the British service. For purposes of comparison, an outline of the suggested 5 mm. (0·1968 inch) rifle calibre is also shown with the other measurements.

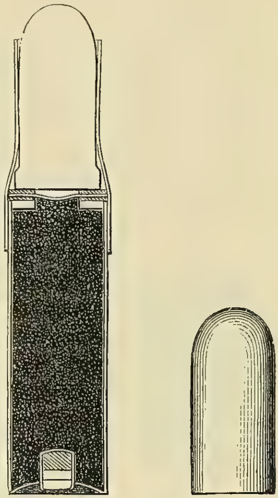
Fig. 26.



Diagrams of Outlines of Small-bore Rifle Bullets. (See description in text.)

French army rifles.—The projectiles of the Chassepôt rifle of the French army, like that of the needle-gun of the Prussian army, are of historical interest from having attracted so much attention in this country during the Franco-German war, and from so many professional observations on the wounds inflicted by them having been published. A short account of them, although they are no longer in use, will accordingly be useful for reference.

FIG. 27.



Chassepôt Bullet and Cartridge.

The Chassepôt rifle had a calibre of 0·433 inch. The bullet was cylindro-conoidal, with a spherical apex; was one inch in length, and nearly half an inch in its greatest breadth (·463). It was solid, made of lead, and its weight was 385 grains.[26] The base of the bullet was a little larger than the calibre of the rifle, so that it might be forced to take the grooves of the rifling. The charge of gunpowder was 85 grains. The initial velocity of the bullet was 1·476 feet in a second. The rifle was sighted for 1000 metres—about 1094 yards.

After the war the Chassepôt rifle was rendered obsolete, and in 1874 it was settled to have a rifle of about the same calibre, but differing in various mechanical details. Subsequently the magazine system of supply was adopted. The new rifle was known in the French army by the name of the Gras rifle, from its system of construction having been proposed by Major Gras, of the French artillery. The calibre of the rifle was 11 mm. (·429 inch). The bullet was hardened by compression of the lead; its weight was not changed. Another rifle, the Kropatschek, was in use in the French navy and also in some branches of the land forces. After a time neither of these weapons was regarded as sufficiently satisfactory, and in 1886 a rifle of smaller bore, the Lebel, of 8 mm. calibre (·315 inch) was issued. It is stated that the breech mechanism of the Lebel rifle and arrangements of the magazine are likely to be changed in accordance with the system adopted in a rifle called the 'Berthier' rifle.

The calibre of the Berthier rifle is ·301 inch, the diameter at the bottom of the opposite grooves of the rifling being ·313 inch, and the rifling one turn in $9\frac{1}{2}$ inches. The bullets are made of hardened lead covered by an envelope of maillechort. The diameter of the bullet is slightly greater than the bore of the rifle, viz., ·308 inch; its length is 1·142 inch, and its weight 205 grains.

It is fired by a charge of 33 grains of smokeless powder, and with this charge the muzzle velocity is stated to be 2071 feet per second. The weapon admits of single shots being fired deliberately, or of rapid firing by means of the magazine supplies. Each magazine contains four cartridges placed together in a kind of packet. One of the special features of the rifle is the simple manner in which the magazine, when emptied, falls down automatically, and admits of being replaced by a full one. The separate magazines, or packets, are carried in a bandolier; and thus supplied, a soldier is said to be able easily to fire off seven magazines, or 28 shots, per minute, in case of need.

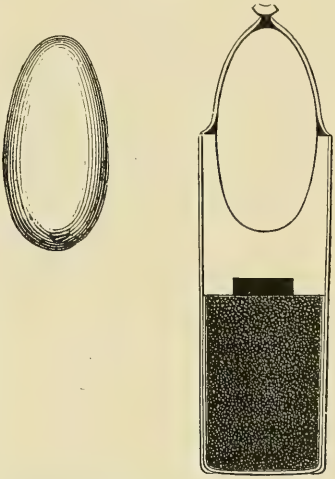
German army rifles.—The celebrated Prussian needle-gun was invented as far back as 1836, by Herr von Dreyse. Four years later, orders were given to supply the light regiments of the Prussian infantry with it, and this was the first breech-loading fire-arm employed in any army. This was the weapon used by the Prussians in the Danish war of 1864, in the war with Austria in 1866, and in the war with France in 1870–71.

The chief peculiarity of the needle-gun was the manner in which the bullet was supported within the barrel, and in which the rotation resulting from the rifling was impressed upon it. The bullet was held at its base in a *zündspiegel*—a papier-maché receptacle, or sabot, formed on the outside to fit the bore of the rifle, and adapted within for receiving the bullet, like an acorn in its cup. The *zündspiegel* also contained, in a central position at its base, the detonating composition. The charge of gunpowder was contained in a small paper bag behind it. When the trigger was pulled in firing, the steel needle was driven through the powder in the cartridge, into the detonating composition above, there being a central hole in the base of the papier-maché cup for the purpose. The gunpowder was thus set fire to in front, and the evolved gas, acting upon the papier-maché cup, which was rather larger than the bore of the gun, forced it into the grooves of the rifle, and caused it to rotate, together with the bullet, which it carried along with it. As soon as the cup and bullet were out of the muzzle of the weapon, the bullet left the cup, and flew alone to its mark. From this description it may be understood that occasionally, when the rifle was fired very near a man, there was a risk of the *zündspiegel* entering his body as well as the bullet, an accident which Professor Gurlt, of Berlin, stated in his description of the projectiles used by the opposing armies in the Danish war of 1864 he had himself seen happen.[27]

The bullet of the needle-gun was ovoid in form, and slightly over 1 inch in length (1·08). When this rifle was first introduced, the bullet was 15·43 millimetres in its greatest width (·609 inch), but being found too heavy and deficient in speed, its breadth was reduced to 13·6 millimetres (or ·535 inch). Its

weight was then 478 grains. These were the conditions in respect to size and weight of the bullet as it was used in the Danish war of 1864, and in the Bohemian war of 1866. Subsequently the weight was reduced from 478 to 324 grains, and the width to ·485 inch. The charge of powder remained 75 grains. The diminution in size of the bullet did not render any change in the firearm itself necessary; the small projectile could still be fired out of the wide barrel by merely giving a proportionate amount of enlargement to the papier-maché cup in which it was carried. The elongated oval form of this bullet caused it to be very easily deflected on coming into contact with the rounded bones of the extremities, or other strong tissues presenting a convex outline, at all distances at which its initial force had become considerably diminished. The chief military disadvantages of the weapon were its unnecessary weight, and its inferiority in range to some other rifles.

FIG. 28.



Needle-Gun Bullet and Cartridge.

After the war was over, the Germans, in 1871, adopted a breech-loading rifle, known, after the name of its inventor, as the Mauser rifle. It had a calibre of 11 mm. (·429 inch); its bullet was made of lead hardened by the addition of 15 per cent. of tin and 15 per cent. of antimony; its weight was 25 grammes (385$\frac{4}{7}$ grains); the charge of powder, 5 grammes (77 grains); and its muzzle velocity was stated to be 1427 foot-seconds. This rifle was subsequently converted into a magazine arm, Germany being the first of the European Powers to adopt the magazine system. The conversion was not regarded as sufficiently successful, and about 1884 it was settled that a new rifle of smaller calibre should be substituted for it. This became the Mauser pattern of 1888, with a calibre of 7·9 mm. (·312 inch). The bullet was made of hardened lead as before, but it was covered by an envelope of steel, plated with nickel. At the same time a new chemical semi-smokeless explosive was introduced for use instead of the old gunpowder, the charge being about 40 grains. This chemical powder gives to the bullet a muzzle velocity of about 2050 foot-seconds. It will be observed that the calibre, hardness, weight, and initial velocity of the German rifle projectile closely agree with the corresponding qualities in the French Lebel rifle.

Austrian army rifle.—The Austrian magazine rifle, the Mann-

licher, with which the Austrian infantry were armed in 1888–90, has attracted much attention, from having been the first small-bore rifle which has been actually used in war. One of the contending parties in the late civil war in Chili was largely armed with this weapon. The bullet used with it is steel-covered, and, like the existing North German pattern, is very similar in diameter, weight, length, volume, and muzzle velocity to the French Lebel rifle projectile. The chief differences are in the breech and magazine mechanical arrangements. The published reports respecting the effects of the Mannlicher rifle in the Chilian war have been very contradictory. While, on the one hand, according to Surgeon-General von Bardeleben, Colonel Boonen-Rivera, who held the post of Brigade-Commander, in reporting on the war, has stated that the number of dead on the battle-field, by his own observation, was four times larger than that of the wounded, Captain v. Heyking, of the German School of Musketry, mentioned in a lecture at Spandau (May 1892) that the reverse was really the case. He quoted another report in which the small proportion of men wounded mortally was remarked upon, and he added that 'the wounds by the Mannlicher are such as either to kill a man outright, or to ensure recovery free from complications or excessive suffering. The bones were clean pierced, even at the greatest distances, without leaving splinters of steel or lead, and the bullets after extraction had retained their original shape.'

The leading features of the magazine rifles of some other foreign armies will be found in the table already furnished on p. 51.

Review of the general effects of the successive changes in military portable fire-arms and their projectiles on wounds inflicted in warfare.

The early kinds of portable fire-arms, or hand-guns, owing to their very primitive construction and mode of discharge, were probably hardly so destructive as the cross-bows in use at that period; although from their novelty, together with the flame and loud report which accompanied their discharge, the consternation they caused was doubtless far greater. Military cross-bows are recorded to have been capable of killing a man up to 60 yards at point-blank range, and up to 160 yards when duly elevated. The heavy, cumbrous hand-gun, with its wide and uneven bore, ill-fitting projectile, and ill-made powder, could scarcely have been used with such precision and deadly effect. The improvements subsequently made in the construction of the weapons, as well as in the quality of the gunpowder, gradually led to higher initial velocity, increased force, and a more extended range in the missiles discharged from them. The later improvements in smooth-bore fire-arms do not seem to have changed the severity

of the wounds produced by them so much as they did the power of inflicting severe wounds over a still wider area; but the number of wounds resulting from discharges of shot became greater, and the relative proportions of these wounds in respect to different degrees of gravity were altered. In very early times, after some of the leading imperfections of the primitive hand-guns and muskets had been removed, if a soldier happened to be wounded at very short range, the wound might be as severe as one by the most improved weapon in use prior to the introduction of rifled muskets. But such severe wounds were only, as a rule, met with in accidental collisions; the greater number of wounds in early battles seem to have been inflicted at distances beyond the range at which such extreme effects could be produced. A large proportion of them were therefore of a comparatively slight nature; for the projectiles in use quickly lost their velocity on account of their imperfect shapes and other defects, and, on striking, were able to do little more than glance from the armour which was worn for many years after fire-arms were introduced, or just to wound the surface when they penetrated the body. Hence, doubtless, the large number of recoveries reported in early surgical works on gunshot wounds, especially of recoveries after injuries of the trunk and head. The introduction of rifled weapons led to results similar to those which followed improvements in smooth-bore fire-arms, but in a far greater ratio. The sustained energy of projectiles discharged from rifles, not interfered with by expansion of the fire-arms from heat, or by the other disturbing influences which quickly lessened the energy of bullets projected from smooth-bore muskets, gave to combatants a vastly extended range over which a powerful fire could be maintained, and to military surgeons a proportionally increased number of severe wounds to treat.

The different effects produced by the smooth-bore weapons used by British troops, even down to the first half of the present century, when compared with those resulting from the improved rifles of later days, have been illustrated in comparatively recent campaigns in which British forces have been employed against tribes in a half-civilised condition. In the war on the Gold Coast the rifle was used, on one side, against very imperfect smooth-bores, and badly made projectiles on the other. In the New Zealand war the relative condition of the opposing troops, so far as their fire-arms were concerned, was nearly the same as on the Gold Coast. So also in the Caffre war and in the China wars of 1857 and 1860. In the wars on the Gold Coast and in New Zealand, when the Ashantis or Maoris managed to creep by stealth through the bush, so as to be enabled to discharge their muskets at very close range, the wounds inflicted were sometimes of the severest kind, and in particular cases fatal; but the majority of the

wounds which were caused by the same weapons when fired at greater distances were of a slight and comparatively trivial character. Out of 211 wounds inflicted in action on British troops in the Ashanti war of 1873–74, only 18 entailed fatal consequences, either in the field or subsequently.[28] On the other side, the Ashantis are said to have lost heart because frequently they were hit at such long distances that they could not see the enemy who fired at them, and because, in the majority of instances, when they were hit, the wounds proved fatal.

The change to rifled fire-arms, and the altered forms and modes of motion given to their projectiles, affected gunshot wounds not only in regard to the distance at which they could be inflicted, but materially influenced in many instances their very characters, and the surgical treatment they required for their cure. The conversion of muzzle-loading into breech-loading weapons has not made any alteration in the wounding range of the weapons; but it gave the opportunity of firing explosive and hardened bullets, which could not well be used with muzzle-loading fire-arms. Had explosive bullets been permitted to be employed in war, they would have exerted a fresh and serious influence on the characters of gunshot wounds. The use of hardened bullets has tended to modify them to some extent. The experience afforded by the use of the Prussian needle-gun and the French Chassepôt did not exhibit to surgeons any material change in the characters or features of the wounds inflicted by them. But the bullets used with the Prussian needle-gun and French Chassepôt were soft leaden bullets like the old musket bullets. The rapid, almost uninterrupted, discharge of projectiles that was kept up for a time on certain occasions by these breech-loaders, and consequently the enormous number of wounds which were produced among the particular bodies of troops subjected to their fire, within very short periods of time, was the result of their use which chiefly attracted the attention of military surgeons, because of the increased difficulties they met with in giving the necessary care and treatment to the wounded.

Speaking roughly, the change from the smooth-bore to rifled weapons gave ten times the range, with greatly increased precision of aim; while the change from muzzle-loading to breech-loading weapons, without altering the range or their accuracy, increased the capability for rapidity of fire tenfold.

The alterations that have occurred during the last three or four years in military rifles and their projectiles—the reduction in calibre of the fire-arms, the introduction of compound projectiles, and the use of new explosives in place of gunpowder—have led to extremely important changes in the general aspects of war, as well as in the characters of many of the wounds which are likely to be inflicted in the future at remote distances.

So far as Europe is concerned, the effects of the new weapons have only been observed, with a few accidental exceptions, experimentally; they have not happily been experienced in actual war. The reports which have been published regarding the results of their partial use during the civil war in Chili have been contradictory. But it is beyond question that the changes referred to have caused a very great increase in the velocity both of translation and rotation of the bullets, in their accuracy of flight over extended ranges, and in their penetrative capacity. The increase in hardness of the surfaces of the projectiles, at the same time the fact of their weight being sufficiently maintained by the core of heavy lead within, effect results which not only help to increase the power of penetration of these narrow missiles, but also enable them to maintain this power over distances at which the rifle bullets in previous use had parted with considerable portions of their energy. Another important consequence of the great reduction in the diameters of rifle projectiles, surgically regarded, is the fact that, with the narrowing, there has been a proportionate exclusion of air, and of all the irritant and morbific germs which air contains, from the openings and interior surfaces of wounds caused by them. When, therefore, the wounds are confined to some of the soft and yielding tissues of the human body, they become nearly analogous to subcutaneous wounds. The special qualities of the new projectiles, however, will be more particularly considered in another section.

Projectiles of Exceptional Kinds used with Portable Fire-arms.

In default of regular projectiles, and under circumstances of urgent need in warfare, anything capable of being used as a projectile with fire-arms may be expected to be employed for the purpose. In insurrections and civil wars especially, various things within easy reach, such as nails, toy marbles, fragments of stone, gravel made up in packets, round metal buttons, and bits of glass, have been resorted to for inflicting wounds in addition to the projectiles in ordinary use. During the war of the Sepoy Mutiny in India in 1857, the Sepoys frequently used small sections of telegraph wire in the absence of better projectiles. The Maoris also, during the last New Zealand war, occasionally used pieces of telegraph wire when their regular bullets were expended, as well as bits of round iron rods that had formed portions of fences. In a case of extensively lacerated wound in an English soldier, a long rectangular piece of iron was found lodged in the wound. The Maori had fired this missile at a short distance from the wounded man.

The projectiles used with fire-arms by nations in a half-savage condition are usually very irregular in shape, and consist of very

heterogeneous materials. The leaden bullets used by the Ashantis during the war of 1873–74 were never truly spherical in form, and varied greatly in respect of size and weight. They commonly employed, especially in the latter period of the war, angular slugs of iron, as well as fragments of a dark siliceous ironstone. The iron slugs were cubes varying in dimensions from $\frac{1}{4}$th to $\frac{3}{8}$ths of an inch square, and appeared to have been cut from rectangular iron rods. Occasionally these slugs were hammered into a somewhat spherical shape. The nodules of ironstone were of no regular form, and of all sizes that could be turned to account for charging a musket. Even glass beads were employed by the Ashantis when other kinds of ammunition grew scarce.

The bullets used by the Kota Lama Malays against the British troops in January 1876 were made of tin, which is found plentifully in the Malay Peninsula; while lead, it is understood, has not been discovered there. They were fired as they were cast in the bullet-moulds, without being trimmed, so that they often had a projecting portion or tail, representing the tube through which the molten metal had been poured into the mould; and also a sharp-edged belt of tin with uneven adjustment of the two hemispheres of the bullet, owing to the two parts of the mould not having been properly closed. Small fragments of earthenware, china, or pieces of glass, were imbedded in all of them. It is uncertain what the motives were for these additions to the tin. The specimens sent to the Museum at Netley by Surgeon-Major Collis, from Malay, vary in weight from 154 to 287 grains.

It has been mentioned by M. Scrive that double bullets, linked together by a spiral coil of slender wire, something after the manner of the chain-shot which used to be employed for cutting rigging in naval warfare, were used by the Russians during the war in the Crimea. Specimens of these bullets were found about the works around Sebastopol, but no injuries received from them have been recorded, although after their discovery peculiarities in the characters of some wounds, which had not previously been satisfactorily accounted for, were supposed to have probably resulted from them. It seems likely that, if discharged, the divergent forces impressed on the two bullets would be sufficiently great to break apart the thin connecting wire before they reached the troops against whom they were directed. Colonel Rennie presented to the Military Surgery Museum at Netley a pair of bullets linked together by two loops of stronger wire than seems to have been employed in the spiral coils of the Russians. The loops are each an inch and a half long, so that the bullets are three inches apart when stretched out. Linked bullets of this kind were used by the matchlock men in Oude during the Indian mutiny.[29]

Count Bismarck, in a despatch dated Versailles, January 9,

1871, relative to the manner in which the French had carried on the war, stated that 'a cartridge has been found in the pockets of French prisoners, the ball of which is divided into sixteen segments, and loosely joined again. One of the many specimens of this sort of projectile, which is tantamount to chopped lead, has been sent to the Foreign Office at Berlin, and will there be submitted to the representatives of the Foreign Powers.' The idea that bullets are made more destructive by division into segments, or by furrowing their surfaces, has often been put into practice in irregular warfare and in civil conflicts. A cartridge containing the ounce-bullets used with a revolver-gun, or a buckshot cartridge, would evidently be far more effective, for the angular shapes of the cut segments must quickly lead to their force being spent in passing through the air.

It is mentioned in the 'British Official History of the Crimean War' (vol. ii. p. 262) that slugs were extensively used by the Russians on the occasion of the assault of the Redan on the 8th of May, and that they were made up for muskets like the grape-shot for larger guns. As the slugs were then employed at close quarters, they were well calculated to increase the number of wounds inflicted on the assailant troops.

Explosive bullets.—Hollow bullets charged with explosive materials, and prepared for acting on a small scale in the same manner as large shells, were known to English officers many years ago. They were designed both for sporting and for military purposes. Nearly seventy years have elapsed since Captain Norton invented his celebrated rifle shell. The 'Jacob' and other shell bullets followed. About the year 1862, after numerous trials, an explosive projectile for portable fire-arms, known as the Metford shell bullet, was adopted for use in the British army.

Incendiary and explosive bullets were also introduced within a few years of the same date in the armies of Austria, Prussia, United States of America, Russia, Switzerland, Bavaria, and probably in those of other countries. The powerful explosive bullets invented by Herr von Dreyse, and adapted for use with the breech-loading needle-gun of the Prussian army, particularly excited the attention of military surgeons.

The explosive bullet employed by the United States army was known as the Gardner 'explosive bullet' or 'musket shell.' According to the 'Surgical History of the War of the Rebellion,' 33,350 of these explosive missiles were issued to the United States troops in the early part of the war. But 10,000 of these were abandoned in the field from want of transport, and it is stated to be probable that they fell into the hands of the Confederates. If it were so, it would account for some of the wounds from these projectiles among the Federal troops. One hundred and thirty cases of such wounds were recorded in the hospital returns, but

it is doubtful whether some of them were really caused by explosive bullets.

In the year 1863, an incendiary bullet, filled with an explosive powder, and fitted with a percussion-cap, was introduced into the Russian army. On striking against a hard substance, the shock caused the inflammable material within to be ignited. This projectile was specially designed for blowing up ammunition waggons. In 1867, another description of explosive bullet for use with rifles and mitrailleuses was proposed for use to the Russian Government. This projectile contained a fulminating composition, and was so constructed that its contents would explode if it were fired through a sheet of paper, or brought into collision at high speed with a soft substance, such as the human body. The ignition of the contents of this bullet caused the projectile to burst into fragments, which did not happen with the incendiary bullet adopted in 1863.

The Russian Minister of War, General Milutine, considering the use of these projectiles in war to be of very doubtful advantage, while their employment would almost certainly aggravate the sufferings of the wounded, proposed to renounce their employment in the Russian army. The Emperor Alexander joined in the views of the Minister, but convoked a conference in which all Governments were invited to take part by their representatives at St. Petersburg, in the hope of getting a similar rule adopted in other armies. This act gave rise to the International Military Commission, which held its first sitting on the 28th of October 1868. The result was an agreement by the principal military Powers of Europe to abstain from the use of all explosive projectiles less than 400 grammes in weight. The motives which induced the conclusions arrived at, and the text of the treaty on this subject, will be found in the Appendix.[30]

Notwithstanding the international agreement just referred to, there has been great misgiving on the part of many as to the abandonment of explosive bullets in time of war. The Government of the United States would not join the Convention, and the treaty is only obligatory upon the contracting parties when at war between themselves: it also ceases to be obligatory in case of a Power which has not joined the Convention allying itself to either one or other of the belligerents. The English Government of the day was greatly blamed by the Press and by many military men for joining the treaty.[31] It was argued that England ought not to submit to arbitrary rules restricting her mechanical skill, which she must rely on to counterbalance her numerical inferiority in troops and guns; and it was further urged that, whatever treaties might be made on such subjects, any struggle for self-preservation would certainly override them.

It may be useful, therefore, to describe briefly the construction and qualities of these projectiles, and the influence they are

calculated to exert upon the characters of any wounds, should any be inflicted by them. The description of one or two forms will suffice.

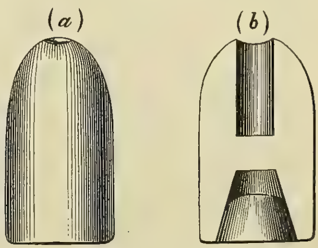
Construction of shell bullets.—There is very little change in the essential features of construction of any shell bullets since they were first invented in 1822 by Captain Norton. The changes made in them have chiefly depended on the alteration of fire-arms from muzzle-loaders to breech-loaders. When incendiary, or, more particularly, fulminating bullets were used with muzzle-loading arms, a certain amount of risk to the persons using them in forcing them down the bore of the fire-arm could not be got rid of. When the bullet had to be simply placed in a receptacle fitted to receive it at the breech of the fire-arm, this risk was removed.

The bullets invented by Captain Norton were of two kinds—one containing ordinary gunpowder, the other fulminating powder. In both kinds the bullet was somewhat elongated in form, rounded in front and behind, and presented, on its lateral surfaces, projections adapted for being placed in the grooves of a rifle. Each bullet contained a cylindrical cavity, about the third of the width of the bullet in diameter, and extending from the front nearly to the base of the projectile.

In Captain Norton's detonating bullet, the concussion or striking force was obtained on the shell meeting its object, through the medium of a plug of wood inserted into the head of the bullet. In his incendiary bullet the explosion of the gunpowder, which was held in a small metal case within the cavity of the bullet, was effected by an ordinary percussion-cap. General Jacob's 'rifle shell' was similar in principle to the last-named explosive bullet.

The Metford explosive bullet, which was adopted in the British service for use with the converted Enfield rifle, differed in some essential features from the bullets above described. The cavity containing the fulminating powder was stopped at the apex of the bullet by a plug of wax. At the base of the bullet (fig. 29) was placed a wooden plug. The effect of this arrangement was, that in the passage of the bullet through the fire-arm the plug at the base so compressed the detonating powder and wax, that on the bullet meeting any obstacle in its flight, even a sheet of paper, the shock was sufficient to cause the explosion of the fulminate and the dispersion of the bullet in fragments. The length of the Metford bullet was 1·06 inch, its diameter ·55 inch; its weight when empty was 525 grains, and when filled 582 grains.[32]

FIG. 29.

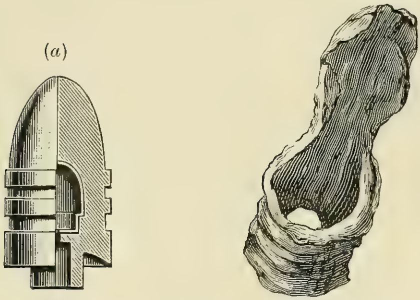


(a) Metford Rifle Explosive Bullet; (b) Section of Bullet empty.

The Gardner explosive bullets of the United States army were cylindro-conoidal leaden bullets, and were of two sizes—the larger having a diameter of ·58 inch, and weighing 451 grains; the smaller being ·54 inch in diam., and its weight being 363 grains. Within the projectile was an acorn-shaped chamber which was filled with fulminate, and was in communication with a $1\frac{1}{4}$ time fuze. The fuze was ignited by the flame at the moment of discharge. The shape of the bullet, and the arrangement of the fulminate chamber, are shown in (*a*) fig. 30, and the appearance of one of these bullets after explosion, and extraction from the thigh of a wounded soldier,[33] is shown in (*b*) fig. 30. Both (*a*) and (*b*) are copied from the U.S. Surgical History of the War.

Fig. 30.

(*a*) (*b*)



(*a*) Gardner Explosive Bullet. (*b*) Gardner Explosive Bullet extracted from Wounded Thigh.

Qualities of shell bullets affecting wounds.—Surgically regarded, there is an essential difference between the larger kinds of shells previously described, and shell bullets. The former are designed for bursting before reaching their object, and then inflicting wounds by the fragments into which they become broken; the latter are intended, first to penetrate the objects they are aimed at, and then to inflict further injury by their explosion.

It is evident, therefore, that on the explosion of a projectile of this latter description within a limb or cavity of the body, not only the forcible penetration of the projectile, but also the effects of its enlargement and distortion if simply expanded and ruptured by the explosion, or of the violent dispersion of its fragments if broken into pieces, which would usually happen, together with the distending force and particular qualities of the gases and residuum evolved by its explosion, must all be taken into account when its injurious effects on the human body are considered.

The effects of the Gardner explosive bullets are described in the History of the United States war to have been as follows. The extent of damage done was greater than that caused by simple bullets: bony structures were more extensively shattered; the area of destruction in the soft parts was larger; hæmorrhage, both primary and secondary, was more common; sloughing more extensive; and repair more slow and tedious. The particulars

of some well-authenticated cases of wounds by explosive bullets are cited in the History, as are also a series of alleged wounds from them.

Small Shot used with Fowling-pieces.

The shot employed for sporting purposes occasionally cause gunshot wounds in civil life, and when a charge of shot inflicts a wound at a short distance from the gun, it is often attended by specially hazardous features. Gunshot wounds also sometimes occur from shot discharged from 'saloon pistols,' miniature cannon, and other toy weapons sold for purposes of amusement. A few years ago I procured from one of the best known London gunsmiths,[34] for examination, specimens of the shot of all sizes used for sporting purposes. The numbers and marks by which the shot were distinguished from one another, and the numerical proportions of these shot to weight, are shown in the following tables. They still retain the same designations, but the precise weights and sizes slightly differ in specimens from different manufacturers.

Small Shot.

Designation of Shot.	Number of separate Pellets to 60 Grains.	Designation of Shot.	Number of separate Pellets to 60 Grains.
No. 1	13	No. 8	70
,, 2	15	,, 9	100
,, 3	20	,, 10	180
,, 4	25	,, 11	200
,, 5	29	,, 12	257
,, 6	39	Dust	334
,, 7	53		

The diameters of the pellets gradually diminished from ·145 of an inch, that of No. 1 shot, to ·045, that of dust shot. The next table shows the weight and diameters of some of the larger kinds of small shot used for sporting purposes :—

Small Shot, Larger Sizes.

Designation of Shot.	Weight of each Pellet.	Diameter of Pellet.
A	9 grains.	0·180 inch.
AA	10 ,,	0·190 ,,
AAA	13 ,,	0·200 ,,
B	6 ,,	0·152 ,,
IB	8¾ ,,	0·160 ,,
IIB	10 ,,	0·200 ,,
S.S.G.	31½ ,,	0·300 ,,
S.G.	51 ,,	0·325 ,,

The shot mainly consists of lead, but is sometimes hardened by the addition of a small proportion of arsenic, sometimes by a process of 'chilling.' The separate pellets being sometimes composed of soft and at other times of hardened material, necessarily affects their respective power of penetration, especially when bone is concerned, and occasionally explains the different depths at which shot from different charges are found to lodge in accidental wounds of the face when the injuries have been received at corresponding distances from the points of discharge. The pellets of shot, although they may be spherical when manufactured, are subjected to more or less disfigurement by being forced against each other while passing along the barrel of the gun, and the amount of this deformation is greater when a violent chemical explosive is used, than when the relatively slow-burning black or brown gunpowder forms the charge. This also affects their depth of penetration.

CHAPTER VI

ON LIQUID AND GASEOUS PROJECTILES

Fluid projectiles.—Although substances in the fluid state are not employed with guns as projectiles, it is well to remember fluids are capable of inflicting wounds if the necessary velocity be impressed upon them. Water has been occasionally employed by soldiers on the Continent as a means of suicide. A rifle having been loaded in the ordinary way, and a wad of mashed paper or rag rammed down the barrel against the charge, water is poured in, and secured in position by a cork. The head of the soldier is then placed opposite to the muzzle and the gun fired. The cork would probably suffice to kill under the circumstances. General destruction ensues from the immense projectile force of the column of water, and life is extinguished before the bullet reaches the victim. The idea has seemed to be that the bullet alone might perchance fail to inflict a mortal wound, or at any rate would not cause such extensive, and therefore such speedy and fatal, destruction as the column of water and bullet combined.

In Professor Abel's water-shell the water is not used as a projectile, but only for transmitting the disrupting force to the substance of the shell.

Liquid incendiary projectiles have been occasionally employed in war. In regular warfare they have been employed for setting fire to storehouses, ships, magazines, and other military buildings. The celebrated 'Greek Fire' of early times seems to have mainly consisted of coal-tar, naphtha, and turpentine or petroleum, mixed

with a certain amount of phosphorus. It has been stated that a liquid called 'Greek Fire' was used at the siege of Charleston in 1863, but such representations were made respecting its barbarity, that the use of it was abandoned.

A shell specially constructed to receive molten iron, known as Martin's shell, from the name of the inventor, was at one time included among the projectiles of the British service. The shell was lined with a non-conducting coating of loam, to retain the iron in a liquid or semi-liquid state. The shell was so formed that on striking the object against which it was directed, the concussion broke up the shell and scattered around the molten iron which was contained in it. Although designed for being fired against wooden ships and buildings in besieged fortresses, the terrible nature of the wounds which would result in case of spurts of the red-hot viscid iron striking men standing near the object against which the shell was broken, may be easily conceived.

Gaseous projectiles.—The injuries occasionally produced by the gases resulting from exploded gunpowder, independently of the wounds which may be caused by the solid projectiles which they set in motion, are frequently considered under one only of the accidents which are liable to result from them, viz., burns. But many serious lesions result from explosions, without any burning of the injured persons accompanying them; and in the cases where the flame of the explosion reaches the surface of the body, the scorching which it produces is usually complicated by other conditions, which materially influence the gravity of the local injury and the effects of treatment. The most important of these lesions, especially in its general influence on the frame of a soldier, is that which results from the sudden violence of the blow given by the exploded gunpowder, itself acting as a projectile, or by the waves of air which are driven onward by it. Under the circumstances named, the effects of the gaseous impetus impressed on a soldier are usually diffused and general; but in special cases the force of the gas may be so directed that the principal damage done is concentrated locally on some particular portion of a man's body or clothing. A sergeant during the Crimean war had his tunic ripped open, the button-holes being torn from the buttons, from standing too near to the side of the muzzle of a gun when it was fired; but he himself was not injured. In another case a gunner had his arm broken under similar circumstances. There was no open wound, but the front of his tunic was torn to pieces, some of the cloth hanging down in strips. In this instance the man had been 'ramming home,' and was not quick enough in falling back to get clear of the line of issue of the exploded gas. On neither occasion had the men been scorched by flame or struck by any solid substance. The frequent rupture of the tympana of the ears among men in the service, from the discharge of fire-arms,

is due to the same cause. The case of the Duke of Wellington, who had the tympana of both ears ruptured from appearing unexpectedly a little distance off in front of a howitzer just when it was fired, is a well-known example.

When a body of gas is suddenly evolved by the ignition of an explosive compound, the violent propulsive force to which it gives rise is well illustrated in the ordinary projection of the solid missile from a gun or rifle. If not acting upon a projectile specially prepared to be subjected to its impulse, the force will be exerted upon the first opposing object within the sphere of its explosive effects, such as a person standing near; the amount and character of the force being determined by the volume and degree of compression of the gas, the rapidity of its evolution, the concentration of its action according to the manner in which it is directed, and the nearness of the object upon which it acts. In this way it is that the gases derived from the conversion of solid explosive compounds are capable of striking men with concentrated force, and so of becoming *direct* causes of injury in connection with fire-arms. If no solid objects be near at hand, the evolved gases may cause the surrounding atmosphere to become an *indirect* cause of injury, through the impulse communicated to it, just as direct solid projectiles give rise to secondary, or indirect, projectiles by propulsion. The hurts thus produced are real 'wind contusions,' not mythical ones, like the wounds which have sometimes been attributed to 'vent de boulet.' They are met with under various circumstances in military practice. The volume of gas may be projected from fire-arms, from the bursting of shells, from explosions of gunpowder in cases and magazines, or from the discharge of mines, sunk shells, fougasses, or torpedoes. The amount of force which may, under particular circumstances, be developed by the gaseous agents under consideration, has been already referred to when remarking upon the general qualities of the explosive compounds which are employed for military purposes. The nature and characters of the injuries resulting from them will have to be described hereafter.

Projectile-air in wounds.—Atmospheric air has been considered by some military surgeons—the eminent Austrian surgeon Neüdörfer among others—to act under particular circumstances as a direct gaseous projectile. The name *projectile-air* has been applied to it under the conditions referred to. The so-called 'explosive effects' exhibited in some serious gunshot wounds have been ascribed, not simply to the destructive energy of the solid missiles concerned in their infliction, but also in part to the action of a certain amount of air which had been forced into the wounds by the missiles at the moment of their entrance. When an ordinary bullet which has been discharged from a fire-arm with high muzzle velocity, strikes an object while it still possesses

great energy, it is said to compress and carry in front of it a small column of air, and it is argued that this air, being urged onward in its compressed condition, effects an entrance through the integuments and subcutaneous tissues before the solid projectile. After the bullet has entered, according to those who hold the view mentioned, the compressed air aggravates the damage done by the bullet, inasmuch as the air exerts an expansive force in its efforts to resume its original volume. The amount of mischief done varies primarily with the shape and other qualities of the bullet, but it is the projectile-air which is the principal agent in producing the tearing of tissues, and in widening the sphere of injury, in those wounds which have been styled 'explosion wounds,' from the appearances presented by them resembling the appearances which result from the bursting of an explosive bullet. The larger the bullet in volume, the more obtuse its front, and the higher its speed, the greater the quantity of projectile-air forced before it, and the more extensive its effects. It is to the air such as has been described, that Professor Melsens of Brussels first gave the name of 'projectile-air.'

Certain experimental observations have been advanced in support of the views just explained. Chief among them are the following.

When a spherical musket bullet is dropped from a height of several feet into a vessel containing a column of water, a certain amount of air is visibly carried into the water with it. A small amount of air is also retained by the water in closing upon the opening made by the entrance and passage of the bullet through it. Part of the air is disengaged before the bullet reaches the bottom of the vessel, and, after it has touched the bottom, a large bubble of air usually becomes separated from it, and rises to the surface together with some smaller bubbles. The volume of air thus carried in by the bullet has been estimated at twenty times the volume of the bullet itself.

A spherical pistol bullet having been fired by a relatively weak charge into a column of water in a suitably arranged cylinder placed horizontally, it was ascertained that the volume of air carried by it into the water was at least 100 times greater than the volume of the ball.

Observations of the impressions left upon bullets which have been fired against solid substances, have been cited in order to show that a layer of compressed air had existed between the bullets and the targets; but the observations themselves, as well as the deductions drawn from them, have been disputed, and they certainly appear to have been of a very doubtful character.

It is beyond doubt that air is frequently found in contused penetrating wounds, not only in the wounds caused by fire-arm projectiles, but also in wounds caused by blunt instruments of

various kinds. In the case of a man who fell from a height upon the spike of an iron rail, only a superficial wound of the chest being inflicted, the quantity of air pressed into the tissues connected with the injury was a very noticeable occurrence. The presence of the air in this instance led to a curious misinterpretation of the nature of the case.[35] A limited amount of emphysema has been frequently noted as a primary feature in gunshot flesh wounds, particularly about the lips of the wounds. In some of these instances the air has appeared to have accompanied the weapon or missile in its passage, and to have been pressed into the tissues by it; in others, especially in wounds caused by bullets of large size, the air has apparently followed the entrance and passage of the projectile. In no instance of the kind have I seen noted such a forced penetration of air into the neighbouring tissues as might be expected to result from compressed air suddenly assuming its normal volume.

The explosive effects, as they have been termed, produced by projectiles armed with very high rates of velocity, the great damage done, and its wide diffusion, appear to be explicable by means so much more simple and easily comprehended than the alleged forcible entry of compressed air, that the supposition of its agency in adding to the damage done in gunshot wounds may be dismissed as altogether untenable. Whether, however, any such influence was exerted or not at the time when bullets of more obtuse forms and heavier descriptions were in use, there cannot be the least ground for supposing that the forced pressure of atmospheric air into a wound acts as one of the causes of the great destruction effected in an opposing body by a modern small-bore bullet at short ranges.

SECTION II

ON THE CAUSES WHICH INFLUENCE THE NATURE, CHARACTERS, PROGRESS, AND ULTIMATE ISSUES OF GUNSHOT INJURIES

Introductory remarks.—A gunshot injury is more or less modified in its *primary* characters and degree of gravity by

(A) Conditions appertaining to the projectile by which the injury is caused; and

(B) Conditions appertaining to the part or parts of the body injured.

The conditions (A) appertaining to the projectile are of two descriptions, viz.:—

1. Its physical qualities, as: (*a*) its form; (*b*) dimensions; (*c*) volume; (*d*) weight; (*e*) component substance; and (*f*) density.

2. The qualities impressed upon it by the fire-arm from which it is projected, as: (*a*) the velocity with which it is made to travel; and (*b*) its mode of rotation.

Two other qualities of bullets which at various times have been supposed to affect the wounds inflicted by them may be noticed, viz.: (*c*) heat developed during flight or at the moment of impact; and (*d*) a quality of poison.

The conditions (B) appertaining to the part injured are: (*a*) the angle of impact, or relative position of the part struck to the projectile striking it; (*b*) the site of injury; and (*c*) when penetration has occurred, the subsequent course of the projectile, and the depth to which it penetrates.

Lastly, the *subsequent stages* of a gunshot injury, its progress and ultimate issue, are influenced by a variety of conditions independent of those already named, and mostly extraneous to the injury itself; such as the state of health of the wounded man at the time he was shot, the extent to which he was protected against aggravation of his injury during removal to hospital, and the opportunities that existed of giving adequate care and scientific treatment to him in hospital afterwards.

The circumstances by which the *primary* characters of gunshot injuries, and their degrees of gravity, are liable to be modified, or have been supposed to be modified, will only be studied in the

present section. It need hardly be remarked that it is to the whole of their physical and impressed qualities in combination that the wounding effects of projectiles are due; but as the extent to which these qualities severally exist in different projectiles varies very greatly, it becomes necessary to consider them individually, in order to determine how far each has been concerned in producing the results due to the action of any particular projectile. By a study of this kind the effects of the successive changes in fire-arms, particularly those of the portable kind with their projectiles, and many of the peculiarities of the wounds they have been and are still capable of inflicting, will be more easily comprehended. The several qualities will now be considered in the order in which I have previously named them.

CHAPTER I

(A.) ON THE CONDITIONS APPERTAINING TO THE PROJECTILES THEMSELVES BY WHICH GUNSHOT INJURIES ARE MODIFIED IN THEIR PRIMARY CHARACTERS AND DEGREES OF GRAVITY

1. *Physical Qualities of Gunshot Projectiles.*

(*a.*) **Shape of projectiles.**—As regards the larger kinds of projectiles, differences in their figure or shape exert but little influence on the characters or the gravity of the injuries produced by them. Whether a gunshot have the form of a spherical mass of iron, of a cylindro-conoidal shot, of a Whitworth bolt, or the missile consist of a shell before explosion, or of a large shell fragment of irregular outline, the effect on organised structures, rate of movement, and other conditions being alike, will be the same. General crushing of the textures impinged upon, and violent commotion of neighbouring parts, will ensue, and the projectiles, whatever their shapes, will be equally destructive to life or limb from the mere bulk and weight of the masses of metal of which they are composed.

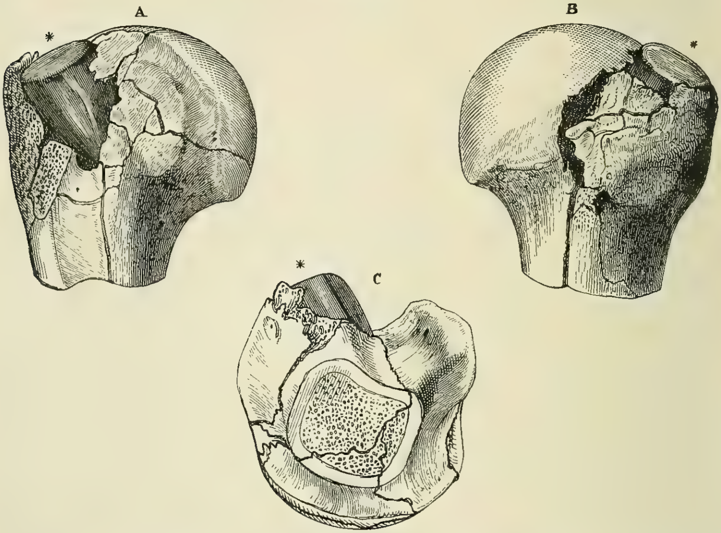
It is in the wounds produced by projectiles discharged from portable fire-arms that the effects of successive variations in shape have been chiefly observed. The altered *forms* of bullets, more especially as regards the change from the spherical to the prolonged cylindro-ogival and cylindro-conoidal forms, and more recently the adoption of bullets of very narrow diameters, have entailed several questions of interest for the consideration of army surgeons. In discussing the subject, however, we must bear in mind that our experience is very limited as to the effects of

spherical musket balls propelled with an amount of velocity even approaching that which subsequent improvements in fire-arms have given to the rifle projectiles in use since the date when spherical bullets were employed. The change, so far as shape was concerned, from the spherical to the elongated cylindro-conoidal projectiles, with their transverse diameters successively declining from 0·69 inch to 0·45 inch, seemed to derive their chief importance in surgery from the shelving fronts of the latter exerting more or less of the mechanical characteristics of a wedge when brought into collision at high speed with living structures, while the spherical bullet acted upon them only as an obtuse body. From possessing this quality, the power of penetration of the earlier conoidal bullets, and together with it the power of splitting asunder hard structures when an opening had been effected in them, became greater. Their penetrative energy and other wounding qualities were thus added to, independently of the force derived from the increased velocity which was maintained by them during their flight. Supposing, therefore, one of the spherical musket bullets to have struck a limb at 80 yards and broken a bone, and an elongated conoidal bullet of corresponding weight to have inflicted a similar wound at 800 yards, at which distances their respective rates of velocity were under ordinary circumstances nearly similar, the injury from the elongated bullet might be expected to be considerably more extensive than that from the spherical bullet, solely on account of its conoidal-shaped front. The wedge-like quality of the conoidal bullet was rendered particularly obvious on its being driven into the shafts of the long bones of the extremities. The solid osseous texture, of which the cylindrical portion of these bones is composed, was split up into fragments having mainly a direction parallel with the central cavity, while the fissures not unfrequently extended from the seat of injury to the terminations of the bones, in the joints of which they formed component parts. Such results were scarcely ever noticed from the impact of spherical balls. The shaft of a bone might be greatly comminuted at the site of impact if the projectile were fired close at hand, but the fragments were generally less elongated and narrow in form, and the long fissuring which was afterwards so frequently witnessed did not usually occur. The hemispherical-fronted bullet, with its large sectional area, struck a wider area of bone, gave a more smashing and stunning blow, and caused more diffused shock and lateral disturbance; the conoidal-fronted bullet of less diameter, a more penetrating and dividing one.

The same difference of effect could be observed on comparing the injury produced on the apophysis of a bone by a conoidal with that produced by a spherical bullet. The splintering caused by the conoidal bullet would probably be found to extend to a considerable distance into the shaft, while not improbably the injury

from the spherical ball would be limited to the immediate neighbourhood of the part struck by it. This difference was obviously calculated to exert an influence, in case of the treatment of the injury by resection, on the extent of bone to be removed. The following sketches (see figs. 31 and 32) of the heads of two humeri which were removed in consequence of wounds inflicted on two soldiers at the battle of Inkerman, one by a spherical, the other by a cylindro-conoidal bullet, well illustrate the relative effects just described. The two bullets happened to strike the same parts

FIG. 31.



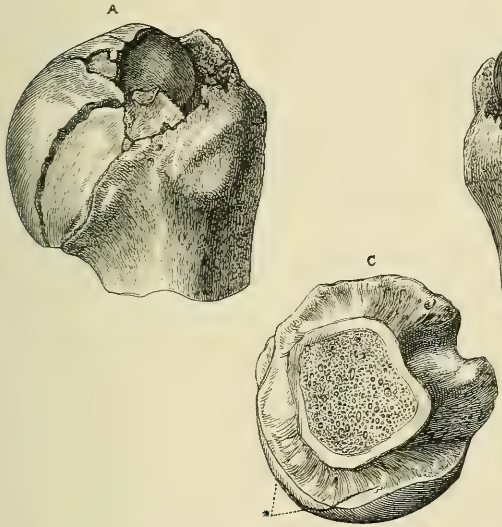
Sketches A and B show the condition of the head of a humerus which has been struck by a *conoidal* ball at the anterior aspect of the greater tuberosity. The bullet has entered, apex first, and is imbedded in the cancellous tissue, its base being on a level with the surface of the bone. Great splintering has followed, and the sketch C shows the fissured condition of the shaft at the part where the operation of resection has been performed. It is probable that these fissures extended some distance in the shaft below the line of resection.

in the two bones, and with about the same amount of force, as shown by the equal depth to which they penetrated; almost the only remaining difference in the two cases being, therefore, the difference in the respective shapes of the two projectiles. The preparations, from which I was kindly permitted to take the drawings, are in the Museum of the Royal College of Surgeons of England.[1]

The greatly increased power of penetration which resulted from the conoidally fronted rifle bullets, other things being equal, is exemplified in the objections which sportsmen generally have to

using cylindro-conoidal rifle bullets when hunting wild animals of a dangerous character. Indian experience has tended to show that for such purposes round heavy blunt shot are preferable. The object of sportsmen is to give a blow that shall hit so hard as to stun a savage animal, since they cannot always depend upon giving one which shall prove mortal; and they use a spherical ball in preference to a conoidal bullet, on the same principle that a bullock may be felled by the back of an axe, the sharp edge of which, though it might penetrate more deeply, would fail to

FIG. 32.



Sketches A and B show the condition of the head of a humerus which has been struck by a *spherical* ball in nearly the identical spot at which the specimen represented in fig. 31 had been struck. The round ball, like the conoidal, has also entered to a distance corresponding with its own depth, its surface being on a level with that of the surrounding bone. Although the head of the bone has been greatly shattered, as shown in sketch A, the rending asunder, or splintering, is very limited, and the saw, in resecting the injured head, has passed through the shaft (see sketch C) without crossing a single fissure; and this, notwithstanding the operation has been performed somewhat nearer to the neck of the bone than in the preceding instance.

knock him over. A writer on elephant-shooting in Ceylon some time ago remarked that he got into dangerous scrapes by using conical bullets with his rifle, though he had them made an ounce heavier than those which he had previously used; the penetrating power was greatly increased, but the stopping power was lost. A belted 3-oz. spherical ball was like a sledge-hammer in its effects, and no animal could stand against it; but the pointed conical bullet went through like a spear-head, and was not so effective as smooth-bored guns with spherical balls. A deer shot

through the belly by a narrow conical bullet would be urged to swifter flight, and escape; a savage animal hit in the same way would be only rendered doubly savage by the pain.

Diffused Concussion attending the Impact of Spherical Bullets.

The diffused concussion, scattering of particles, and shock which resulted from the collision of a spherical bullet with an opposing substance, have been elsewhere alluded to. An instructive fact, because very demonstrative of the effects referred to, was brought to my notice by a gentleman who had been in the habit of firing at fish under water. He got more fish by using the spherical than he did by the elongated rifle bullet. The latter missile seemed to impel a column of water straight on; it did not exhibit the lateral force, or give rise, so far as the fish were concerned, to the stunning effect which the spherical bullet did. The conoidal bullet only killed a fish when it actually struck it; but most of the fish killed or knocked over by the spherical bullets had not been struck by them—they had been some inches, even half a foot it might be, away from them. The fish had evidently been concussed and stunned by the forcible impulse of the water which accompanied the stroke and passage of the large-fronted obtuse projectile. The effects of diffused radiating concussion were still manifested in wounds by the large forms of cylindro-conoidal bullets which immediately followed the abandonment of smooth-bore weapons in the regular service, though not in so marked a degree as they had been when the spherical bullets were used. The occurrence of this diffused concussion has become less and less noticeable in proportion as the diameters of such projectiles have become successively reduced.

Disappearance of wedge-like action with increased elongation in shape.—Although the bullets designed for military uses, when the shape was altered from the spherical to the cylindro-conoidal form, were prepared for the express purpose of more readily inflicting wounds upon human beings and disabling them. very fortunately for the mass of men exposed to be hit by them, the experiments to determine the best forms for ensuring their possessing the greatest practicable amount of wounding power were chiefly made upon sheet-iron, solid oak timber, gabions filled with earth, and other such hard, inorganic substances. Had the experiments been made on substances possessing the qualities of the tegumentary covering and principal tissues of the human body, it is not improbable that a different form of apex from either that of the hemispherical or the conoidal-topped front would have been adopted. Either a pointed conical or pyramidal apex would have increased the piercing power so far as the human body is concerned. The original Minié bullet, which had the same

diameter as the spherical musket bullet, terminated in an apex of the ogival form—a form which meets with very little resistance from the air during flight; and although it never had the same power for opening a way through human tissues that a hard sharp-pointed conoidal or triangular front would have had, yet there can be little doubt that, so far as shape alone was concerned, its form gave it far greater power of penetration than the bullet of spherical form ever had, and more than the blunted conoidal form gave to the pattern which succeeded it. Modern inventive ingenuity, however, has sufficiently devoted itself to the task of overcoming difficulties in respect to penetration, by increasing the velocity, and therefore the force of projectiles; the weapons from which they are discharged being at the same time so constructed as to ensure the despatch of the greatest number of these swift carriers of wounds and death on their fatal errands with sure and certain aim within the shortest limits of time. The penetrative power of bullets of the cylindro-conoidal shape, as compared with that of the spherical bullets previously in use, was increased, moreover, by the diminished diameters of the projectiles which succeeded the Minié rifle bullets; and this increase in power of penetration has been progressively continued in proportion as the sizes of the cylindro-conoidal bullets have been successively lessened. At the same time as the transverse diameters have been decreased, much of the wedge-like action of the missiles has been lost. The splitting wedge-like effects by the Enfield bullets of ·55-inch diameter were very strongly marked, and they were still observable in the wounds inflicted by the ·45-inch bullets; but under the further reductions to 0·4-inch and 0·3-inch they have almost disappeared. The forms of the ·303-inch bullets closely approximate to those of simple narrow cylinders with rounded fronts, and they pass through opposing substances very much as obtuse-fronted needles armed with similar velocity might be expected to do. They have lost all resemblance, so far as shape is concerned, to the early spherical balls or bullets, though they still retain the name in common discourse. The elongation in form of bullets not only leads to certain effects owing to their lessened diameters and lessened sectional areas, but entails other considerations as regards wounds, which will be noticed presently, when the circumstances arising from the varying *dimensions* in length and breadth of the projectiles are studied.

State of surface of a rifle bullet.—In connection with the general figure or shape, the nature and condition of surface of a small projectile require notice, for these circumstances also influence its power of penetrating and passing through the structures of the human body. Manifestly a rifle projectile with a smooth and highly polished surface will enter and traverse the tissues with greater facility than one which is rough and uneven.

In some cylindro-conoidal bullets, several grooves were designedly cut round the cylindrical portion towards the base of the projectile, in order to ensure greater steadiness of flight, and to maintain the apex forward, by imparting a special resistance to the air behind the centre of gravity of the projectile, on the same principle as an arrow is feathered at its tail. (See figs. 20 and 21.) The presence of these grooves, or *cannelures*, as they were technically called, from their resemblance to the fluting on marble columns, although they might lead to greater accuracy of aim for the marksman, increased the opposition to the passage of the projectile through the fibrous textures of the body. In certain instances of lodgment of such bullets, in which the velocity of the projectiles must have been materially diminished before entering the body, it has been evident that the escape of the projectiles was in some measure prevented by some of the textural fibres having been caught in the grooving, and so adding to the impediments to its exit. These cannelures have been abandoned in nearly all modern bullets. In some of the new compound bullets, such as the Lorenz steel-mantled bullets, the ferro-nickel and copper covered bullets, the smoothness and polish of the surfaces from apex to base exist in a high state of perfection. The penetrative energy and traversing qualities of these small-bore projectiles have been largely added to by the evenness of their surfaces.

Alterations in the shapes of bullets from accidental causes.—In studying the causes of the peculiar appearances occasionally presented by bullet wounds, the alterations in shape due to their accidental collision with hard objects met by them in their flight should not be omitted from recollection.[2] Any alteration that may chance to take place in the figure of a rifle bullet before reaching a soldier, if it should wound him, is likely to be attended by an alteration in the size and character of the opening by which it effects its entrance. Deformation of the projectile, even in a moderate degree, will probably be attended by some loss of substance and weight; but whether this occurs or not, there will be a change in the site of its centre of gravity. When once deformed, in its farther course it will no longer spin truly round its principal axis, and can no longer be depended upon to strike an object front forwards. In a perfect rifle bullet, the centre of gravity is so placed, and its manner of rotation is such, that its apex is always kept in advance during its flight.

The ordinary obstacles against which bullets are apt to be brought into collision before troops in the field are wounded by them are stones, gravel, or other hard substances on the ground in front of the men, the rocky sides of ravines, or walls, either of stone or brick, from which the missiles, after striking, may be deflected, and any other solid objects near which the men

may have happened to be standing at the time they were hit. The deviations in form to which bullets are liable from these causes are as various as the forms of the obstacles themselves, or as the angles at which the bullets have happened to be brought into contact with them.

In addition to deviations in form of bullets owing to their impact against objects before they have reached and wounded soldiers, they are liable to deformation from striking against hard objects which are carried by the men or worn on their persons. The iron barrels and wooden stocks of the fire-arms in their hands, the metal portions of their accoutrements, the water-bottles carried by them, are some of the hard external objects by which bullets have been usually thus deformed, and the appearances of the wounds inflicted by them influenced in consequence. Articles of uniform and clothing on the person, and even the toughest of the softer tissues within the body, have but little effect in changing the forms of bullets, though they will occasionally mark their surfaces when they are made of soft lead.

The general effect of the collision of a leaden or comparatively soft bullet with a hard substance is to flatten it out to a greater or less extent, the outer edge of the depressed plate into which it becomes converted being the thinnest part. This thin edge is very often more or less torn, indented, and turned over upon itself. When a solid cylindro-conoidal rifle bullet strikes an iron target in a direct line, the base of the bullet is caused to form the centre of a circular disc. The disc is thickest in the centre, and gradually becomes thinner towards its circumference. The base of the bullet is generally so little interfered with by the collision, that, if it be marked with a number or stamp, especially when the number is within a hollow space at the base, it remains plainly legible after collision. The circumference of the disc is often so thin, in parts where it has not happened to become convoluted, as to present an edge which might readily make an incised cut into soft tissues. This may be taken as the type of all the changes in form which result from leaden bullets striking directly against plain surfaces as hard as iron or brass, whatever the angle at which they strike; but when they strike against convex surfaces, as those of gun barrels, or against uneven surfaces of stone or metal, the modifications are rendered infinite in variety.

After bullets of the softer kinds have penetrated, struck and fractured bones within the body, we find them flattened, spread out, and twisted into every imaginable shape, or divided and broken up into a greater or less number of torn and distorted fragments of different sizes. These varieties depend, in the first place, on the comparative softness of the metal, partly also on the force and direction with which the bullets have come into collision with the outer surfaces of the bones, and partly on the qualities

of the particular bones struck, and the number and shapes of the fragments into which they had become separated. A certain amount of lead usually remains imbedded in the form of minute disconnected particles in the cancellated structure of the broken bone. The particular point of impact of a leaden bullet against a broken bone has often been determined by observation of the spot where granules of the lead could be seen to have been driven in most deeply and thickly into the minute interstices of its substance.

Lessened liability to deformation of armour-plated bullets.—Among the important changes that have attended the introduction of the small-calibre compound bullets, one has been the diminished liability to deformation, whether from accidental causes before penetrating, or from collision with bone after penetrating the body. Such accidents as compression, distortion, division, and planing off segments of the substance of these bullets, are comparatively rare. The fact of the rarity of such alterations of figure among these projectiles is due to the hardness of their metallic envelopes, and extra thickness of their anterior ferules. But as these envelopes in different instances are made of different metals—steel, nickel, copper, or combinations of these and other metals in various proportions—so they vary in their degrees of hardness and elasticity, and consequently in their capacities for resisting deformation on collision with hard substances. Much of this capacity seems to depend also on the nature of the union between the envelope and the core of each bullet. The more intimate the union between the envelope and the core, especially if the core is hardened, as it usually is, by mixing antimony, tin, or arsenic with the lead of which it is composed, the greater the power of the projectile to resist disfigurement and mutilation on striking against such a solid substance as bone. I have seen the Lorenz steel-mantled bullets fired through animal tissues, including bone, and passing subsequently through wood, and lodging deeply in sawdust, without the least perceptible change having taken place in their general figures or superficial smoothness. Of course their velocity and narrowness of diameter conduced to this result; but the hardness of the envelope, together with its close and intimate connection with the core, had undoubtedly the most influence in its production. In other instances in which bullets of similar dimensions and armed with equal amount of velocity were employed, I have seen the envelopes deformed in various ways; and as regards the copper-covered Rubin bullets, I have not only seen the bullets distorted, and the copper covering torn off more or less completely, after collision with bone, but in some instances broken up, and, together with the core of the bullet, scattered in small fragments around.

As regards shape, however, the general effect of the composition

and construction of the compound rifle bullets will be that the original shape given to them in their manufacture will be better maintained throughout their range than happened with the bullets of simpler forms, even though they may be brought into collision with such hard substances as bullets are ordinarily liable to encounter. From this cause a greater uniformity may be expected in the appearances and conditions of the entrance and exit openings, as well as less lateral disturbance and bruising in the tracks of wounds than used to be observed in those inflicted by the relatively softer and more readily distorted bullets which have hitherto been in general use. The power of resisting change of form on collision with hard substances will be least when the velocity of the new bullets is at its highest, so that such instances of disfigurement or separation of substance as do occur may be expected to be usually met with in the first four or five hundred yards of their course, rather than at distances more remote. The alterations in shape that occasionally occur will be more particularly considered when the constitution of compound bullets is treated upon. (See p. 93.)

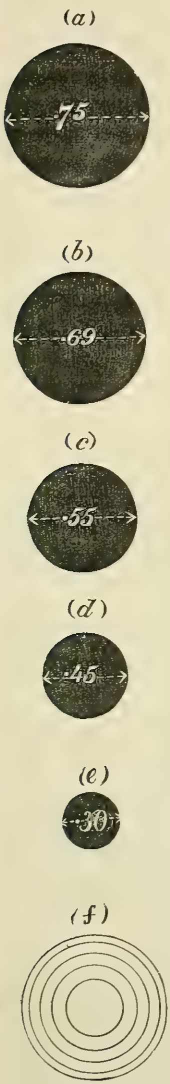
The sharply defined perforations of hard substances, such as sheets of iron, as well as of bones, by the Lorenz steel-armoured bullets, at very high rates of velocity, have been well shown in the large numbers of drawings which illustrate the descriptions in the text of the important work on this subject by Surgeon-General Dr. Beck of the German army.[3]

(*b.*) **Dimensions of projectiles.**—The variations in the lengths of the diameters of bullets are of course accompanied by proportionate differences in the circumferential limits and sectional wounding areas of the projectiles respectively concerned, supposing them to maintain a direct course. The actual differences in the destructive areas of the spherical bullet (*a*) which was used with the smooth-bore musket, and of the cylindro-conoidal bullets used with (*b*) the Minié, (*c*) the Snider converted Enfield, (*d*) the Martini-Henry, and (*e*) the Lee-Metford rifles, are shown in the accompanying diagrams (fig. 33). The circumferential outlines of these bullets may be seen compared with one another at (*f*) in the same figure.

The successive reductions in the diameters of the series of cylindro-conoidal bullets shown in fig. 33, in accordance with the lessened calibres of the rifles from which they are fired, has given to the projectiles a proportionably increased facility of penetrating the human body. Supposing the active force with which two cylindro-conoidal bullets strike an object to be alike in each, and that they act under similar conditions in other respects with the single exception of a difference in their transverse diameters, the bullet which has the less diameter, and therefore the less circumference, will have the greater power to penetrate an opposing

substance. If, for example, two elongated bullets of the same weight as the Snider converted Enfield and Martini-Henry bullets were, should be moving with the same velocity, and were alike in hardness and other qualities, but the one had a diameter, say of 0·50″, while the other, more elongated, had a diameter of only 0·25″, the latter would have double the penetrative energy of the former. The *kinetic energy* of a moving projectile, or the total amount of force which it is capable of expending against an opposing body, is represented by the formula $\frac{MV^2}{2}$, or $\frac{WV^2}{2g}$, but if the comparative *penetrative energy* of two or more bullets has to be considered, then their respective diameters must also be taken into account. The formula for estimating the comparative powers of such projectiles to penetrate substances thus becomes $\frac{WV^2}{2g\pi d}$, in which d represents the diameter in fractions of inches, and the symbol π represents the ratio of the circumference to the diameter, so that πd represents the measure of the circumference in inches. So if d is $=$ ·303″, πd is $=$ ·952″. The penetrative power of the present magazine rifle bullet, with its reduced transverse diameter of ·303″, has thus become considerably augmented by comparison with that of its predecessor, the Martini-Henry bullet, and indeed has become greater, so far as the influence of dimension is concerned, than the penetrative energy possessed by any bullet which has preceded it. Taking the muzzle velocity of the Martini-Henry bullet, weighing 480 grains, at 1315 foot-seconds,[4] with a diameter of ·45″, its penetrative energy with that speed would be in the proportion of 1302 foot-pounds per inch of its circumference, or taking the higher muzzle velocity of 1350 foot-seconds, a penetrative energy of 1372 foot-pounds per inch of circumference; while the Lee-Metford rifle bullet, weighing 215 grains, with a diameter of ·303″, but having a muzzle velocity of 1850 foot-seconds, would on the same basis have a penetrative energy of 1714 foot-pounds per inch of circumference, or with cordite ammunition, and its muzzle velocity brought up to 2000 foot-seconds, a penetrative energy of 2003 foot-pounds per inch of its circumference. Many other conditions act concurrently with its small

Fig. 33.



Diagrams of the Diameters and Outlines of certain Bullets. See description in text.

transverse diameter to give to this latest-contrived projectile its great penetrative force. These conditions are severally described under their special headings.

But other results affecting wounds, which could not take place with the spherical bullets when they were in use, spring from the altered dimensions of elongated cylindro-conoidal projectiles. This influence of the change in dimensions more particularly requires notice, as it serves to explain the great laceration of the soft structures which has occasionally been met with in wounds from elongated projectiles.

In the spherical bullet there could be only one length of diameter in whatever direction the bullet might travel. If moving in a direct line, whatever face might be presented towards the object through which it was caused to pass, the passage opened by it would be invariably of the same width; if rotating on one of its axes, all its axes being equal, the same result would still follow.

But in the prolonged cylindro-conoidal bullets there is no longer only one length of diameter. In one direction, in the Martini-Henry for example, we have a long diameter of slightly more than an inch and a quarter (1·27″), in another a diameter of less than half an inch (0·45″); in the Lee-Metford bullet used with the magazine rifle, a long diameter of an inch and a quarter (1·25″), and a transverse diameter of little more than 3-10ths of an inch (0·303″). Each of these projectiles therefore presents one long axis, the one on which it ordinarily revolves during its flight, and a large number of other axes, of various lengths, but all shorter than the long axis. If such a bullet cleave its way through structures which offer scarcely any opposition to its passage, while it preserves its regular line of flight, the track left by it will be very narrow, because it will correspond in diameter with the shortest of the short axes of the bullet, viz., with the measurement of its width, and not of its length. A narrow cylindro-conoidal bullet maintaining its normal line of flight may pass through an important joint, as has been shown by actual observation, without rupturing the opposite surfaces composing the articulation, or may pass between two adjoining ribs, or other closely connected bones, without fracturing them, under circumstances in which the bullets of larger diameters in former use could not have done so. But if, as will sometimes happen, owing to accidental disturbing causes, it gets a tendency to rotate on one of its shorter axes, or acquires a side to side movement during its flight, wabbling, as gunsmiths call it; or if from contact with some hard substance just before entering the patient's body; or from coming into collision with bone, or other structures, after entering the body; —if from any of these causes it becomes deflected from its straight, directly linear course, then the width of the passage made by it

will not correspond with the shortest diameter of the bullet, but may be very considerably greater. The projectile may, under some circumstances, especially if it be a ricochet shot, even strike the surface of the body 'broadside on,' to use a sailor's phrase, instead of 'end on,' and the opening of entrance and the track through the flesh will then be caused to correspond in dimensions with the length, instead of with the breadth merely of the projectile. If, at the same time, the angle of impact be acute, so as to make the wound to some extent a rasing one, a very large and irregularly shaped wound will result, not unlike that which a small fragment of shell would inflict. These appearances may be presented when the part of the body struck is uncovered: they may be considerably aggravated if, in addition to the bullet, portions of clothing or accoutrements have been carried into the wound at the same time. When one of the cylindro-conoidal leaden bullets was brought into direct collision with a hard substance such as a bone, one of these things usually occurred:—

1. It might perforate the opposing substance, and pass on, retaining its original line of flight.

2. Its progress might be arrested, itself being simply crushed and flattened.

3. It might be separated into one or more portions, which severally pursued their ways in different directions; or

4. It might be caused to pursue its course in a new direction. In this last case, when it happened to be deflected, its line of flight might be simply altered in direction, its original movement of rotation and width of track being retained; or the movements of translation and rotation being both partially checked, the projectile might be deflected and might prolong its passage sideways, that is, with its long axis at right angles to the line of its new course; or the rotation on its long axis might be changed by the resistance it has met with into a partial revolution on one of its short axes, the bullet whirling round somewhat like the spoke of a wheel, when for the distance traversed a much wider wound, and very much more extensive mischief in the way of laceration of the adjoining tissues would be inflicted.

In Crimean days, when the cylindro-conoidal bullets fired from the muzzle-loader Enfield rifle were apt to become lodged in limbs, it frequently happened that one of these projectiles would afford evidence of its having made a partial revolution of this kind from the base of the bullet, instead of its vertex presenting itself beneath the integument at the opposite side of the limb to that at which it entered. The apex of the bullet had been held temporarily at the spot, usually against a bone, where it had met with chief resistance, and this spot had formed a central point round which the projectile had made its partial revolution. It entered apex forwards, but it was excised base forwards.

The changes in dimensions of modern bullets, and in some of their other features, especially in their hardness, have materially modified these effects. The penetrative energy of the Martini-Henry hardened bullet is so great, and still more that of the armoured magazine rifle bullet, that at all the ordinary distances at which wounds are inflicted in war, the structures of the human body, even bones, will hardly offer opposition enough to prevent perforation by them, and there will be very little likelihood of the bullet being itself crushed or divided and broken up into fragments. It may therefore be hoped that although a greater number of penetrating wounds may be inflicted in battle when these narrow bullets are in use, a larger proportion of them will be unaccompanied by the complications just described, to which the softer and broader cylindro-conoidal leaden bullets were liable.

(*c.*) **Volume of projectiles.**—The volume, or the amount of space occupied by one or other of the smaller kinds of projectiles, also exercises an influence on the results of wounds inflicted by them, especially when the bullet remains lodged in some part of the body. A shot from a fowling-piece, and even a small pistol bullet, may not only pass through the tissues of the body without doing serious harm owing to their restricted volume, but will sometimes lodge in important organs, cavities of the body, or other situations with comparative impunity, where the presence of a large rifle bullet, like the Minié or Enfield bullets, would almost certainly have entailed fatal results. A wound of a lung by a small and narrow projectile may heal in a manner which could scarcely occur had the wound been inflicted by one of the larger kinds. The differences in volume of recent rifle bullets is not, however, relatively of great importance. Their differences in dimensions and weight will probably exert more influence than their differences in volume, in case of their lodgment. The volume of the largest bullet used with the Brown Bess musket was equal to a little more than $\frac{1}{5}$th of a cubic inch. The cubic capacity of the muzzle-loading Enfield rifle bullet, weighing together with its baked clay plug about 530 grains (530·8958), was 4 cubic centimetres, and, without plug, weighing nearly 525 grains (524·9821), 3 cubic centimetres; that of the breech-loading Enfield, weighing 480 grains (483·66 with some lubricating wax upon it), 3·9 cubic centimetres; of the Martini-Henry, also weighing about 480 grains (480·2747), 2·56 cubic centimetres; while the cubic capacity of the new magazine rifle bullet, weighing 215 grains (215·0928), is only 1·29 cubic centimetres.[5] It can rarely happen, however, that these differences in the amount of space occupied by the respective bullets, though hardly to be called trifling, will lead to any material variations of effect on the wounds inflicted by them, or on the tissues among which they may happen to be lying, in case of their lodgment.

The measure of the space occupied by small-arm projectiles,

is, however, so intimately associated with the measure of their weight, that the import of the one can hardly be properly estimated without reference to the other. The quality of weight will be next considered.

(*d.*) **Weight of projectiles.**—Differences in the weights of projectiles necessarily exert an influence on the characters of the wounds inflicted by them.

Weight of gunshot.—In the largest kind of missiles, such as have hitherto been projected from field-pieces or guns of position, weight has obviously been the quality which has exerted the most destructive power. So long as sufficient force remained in the masses of iron of which these missiles were composed to carry them forward, so long were their *volume and weight* the most important ingredients in determining the characters and extent of the wounds inflicted by them.

A gunshot or large fragment of shell, if striking at all, must invariably inflict an injury of the gravest character. The weights of such artillery projectiles are ordinarily so great that no diminution of velocity can enable any of them to strike a man with impunity. Although the propelling force be at its minimum, still the momentum is sufficient to cause serious damage. A gunshot is not like a bullet, the weight of which, when there is very little velocity left in it, ceases to be of any account. A bullet, striking at the termination of its path, when its velocity is all but expended, may not cause even a superficial bruise. But a gunshot, under like circumstances, though it may not have destructive power enough to carry away the part of the body struck by it, will certainly cause severe injury; it may be only a simple fracture or dislocation, with superficial though extensive contusion, but more often will cause great laceration of the structures opposed to it, or deep internal disorganisation. The weight of the projectile explains this destructive power. However small the velocity may be, if such a projectile be moved at all, its capacity for overcoming resistance represented by its mass multiplied by the square of that velocity, is a force which no structures of the human body can resist. If the same sized shot were made of some denser material than iron, if it were made of lead, for example, its destructive power would be increased proportionally with the increased density, or nearly as 7 to 11, according to the different specific gravities of the two metals.

Weights of fragments of shells.—The weights of shell fragments vary very greatly from a few drams to several pounds. The velocity impressed upon shell fragments has generally been relatively so moderate in amount, and has been so quickly retarded owing to resistance of the air, that, in the majority of instances, the well-known variableness in the characters and degrees of gravity of the wounds inflicted by such missiles has probably

been due more to the variations in their weights and forms than to any other cause. Important changes will result from the employment of high explosives for the bursting charges of hollow shells. The violent disruptive energy of these explosives will cause the shells containing them to be broken up into a larger number of fragments, and each fragment to be propelled with a much higher degree of velocity than resulted from the use of gunpowder. The fragments consequently will have less volume and weight, but their penetrative energy will be preserved over a more extended area.

Weights of rifle bullets.—With regard to small-arm ammunition, however, the influence of different totals of weight seems to have been often dwelt upon beyond measure, more especially in regard to the comparative surgical effects produced by the heavier or lighter musket and rifle bullets that were formerly in general use. That the power of destruction of small projectiles, as of larger ones, would be increased according as their absolute weight might be increased, their form and other qualities remaining unaltered, especially when they happened to be brought into collision with the hard structures of the body, is of course an obviously correct principle. If two bullets are travelling at equal rates of velocity, and are alike in all other respects, excepting in weight, their total energies, or the blows they would give, would vary directly as their weights vary. This is evident from the formula $\frac{WV^2}{2g}$ which expresses the total energy of a bullet in movement. But it is questionable whether there ever have been such differences in the weights of small-arm projectiles under the conditions named, as to have made the variations of any great practical importance to surgeons so far as the characters of the wounds inflicted by them were concerned. Bulk, figure, hardness, velocity, and other qualities override mere weight in importance. It is a matter of military necessity that a soldier shall carry a certain number of rounds of ammunition to render him efficient as a combatant, and he could not carry the required number if the weight of each bullet were much to exceed the weights of such bullets as the Enfield and Martini-Henry bullets. Now the differences in the weights of the projectiles just mentioned were not observed to exert any practical differences in the gravity of the wounds respectively inflicted by them. It requires a considerable increase in *weight* to make a material impression as regards increase of energy, or power to overcome opposition, compared with what may be obtained by a relatively moderate increase of velocity. Supposing a bullet of a given weight to be travelling at a certain rate of velocity, if its weight were doubled its energy would be doubled; but supposing its weight to remain unchanged, but its velocity to be doubled, the energy of the projectile would be quadrupled. A

bullet like the Martini-Henry bullet, weighing 480 grains, if it were moving with a velocity of 100 foot-seconds, would possess energy equivalent to a pressure of 10·64 foot-pounds, and if its weight were even doubled, or increased to 960 grains—2 ounces troy—and it were moving at the same rate of velocity, it would only have an energy of 21·29 foot-pounds; but if its rate of velocity were doubled, while its weight remained at 480 grains, *i.e.*, if it were moving at the rate of 200 foot-seconds, its energy, or capacity for overcoming resistance, would be raised to 42·59 foot-pounds.

In these smaller projectiles the absolute weight, therefore, considering the limits within which it must be restricted, is not an influential quality such as it is in the larger kinds of projectiles. During the Crimean war some exceptionally heavy bullets were used by the Russians in the defence of Sebastopol, nearly one-third heavier than any employed by the troops of the besieging armies. There were two kinds employed by them, each of which is reported to have weighed about 766 grains.[6] Had these bullets been propelled with equal velocity, they would obviously have inflicted more severe injuries on striking bones, more extensive and destructive areal effects in the soft structures of the body, and more diffused concussion and nervous shock, as well as other disabling effects, than the lighter Enfield bullets, the difference being due principally to their greater volume, but partly also to their greater proportional weight. But the fact was, that either from being discharged from less perfect or less easily handled weapons, or from their velocity being more rapidly retarded during their flight to the English works owing to their greater size, these large bullets did not, as far as the means of comparison were afforded, effect greater injury in the fractures caused by them than the Enfield bullets of less weight and size.

As to uncomplicated flesh wounds, the mere increased weight of the larger bullet made but little difference in the gravity of the injury or the time required for its cure. Owing to the larger size of the track of the bullet, the escape of foreign substances which the missile happened to carry in with it were even facilitated; for there were freer means of exit for the discharges from the surface of the track, and there was less liability to some of the other complications which not unfrequently occurred during the cure of wounds of relatively narrow dimensions in those days.

Mr. Guthrie mentioned, in his notes on the Peninsular campaigns, that having had a wide field for observation of the effects of the heavy British musket ball, 16 ($14\frac{1}{2}$?) to the pound, on the French wounded, he did not think them more mischievous in their results than the French musket balls, 20 to the pound, on the English soldiers; while the advantage of having a greater number of rounds of ammunition was on the side of our adversaries.

It is understood that in warfare the object is not so much to destroy life as to disable antagonists, at least for the remainder of a campaign, and bullets of reduced sizes have been supposed to be fully equal to this object by the British military authorities of late years. The weight of the old smooth-bore musket ball was in some larger kinds 574 grains, but ordinarily 483 grains, or nearly $14\frac{1}{2}$ to the pound; and when the Minié rifle was substituted for that weapon, the weight of the bullet became raised to 680 grains,[7] or about $10\frac{1}{3}$ to the pound. But in the Enfield muzzle-loading rifle projectile the weight was reduced again to 530 grains, 150 grains less than that of the Minié; while the bullet of the converted Enfield breech-loader was lowered still further, viz., to 480 grains. The bullet used with the Martini-Henry rifle was also 480 grains in weight.

In the latest kinds of rifle projectiles, those of the small calibre magazine rifle, the weight of the bullet is reduced to 215 grains—a reduction of 265 grains below the weight of the Martini-Henry rifle bullet. But the differences in the characters of a wound caused by one of these narrow missiles is not so much due to the lessened weight, as it is to the narrowness of the bullet and to other qualities associated with this narrowness. If the bullet were made entirely of platinum, when its weight would be approximately doubled—figure, diameter, velocity, and all other conditions excepting material and weight remaining the same—there is no reason for anticipating there would be any noticeable difference in the features of a wound inflicted by it. If the material of the two projectiles were to remain alike, and the weight of one were augmented by increased bulk, then the character and features of a wound inflicted by the heavier bullet would differ in various respects from one made by the smaller and lighter bullet. The weight of a rifle bullet presents several features of importance from a ballistic point of view, but even in this regard it is less a matter of the absolute weight, than one of its weight in conjunction with its diametric dimension. The power of a bullet to overcome the resistance of the air opposed to it in its flight, and so better to prevent loss of the velocity and consequent energy originally impressed upon it, not only depends upon its form and other qualities previously described, but especially upon its sectional density, *i.e.*, its weight relatively to its transverse sectional area. It is this relation which is usually described as the *sectional density* of a bullet. By noting and comparing the relations between the areas of the greatest cross sections and weights of the bullets used with different rifles, their respective retardations in consequence of the resistance of the air, supposing them to be moving with like rates of velocity, may be readily calculated. In the treatise on Military Small Arms, published in 1888, there is a table in which calculations of this nature are given with respect to the different rifles in

use at that date in the principal armies of Europe. From this table it appears that the retardation which the Enfield rifle bullet, 0·57″ in diameter, would undergo in passing through the air would be greater than that of the Martini-Henry bullet of 0·45″ diameter, if they were travelling at a given moment at the same speed, in the proportion of 4·8 to 2·9 The weights of these two bullets were alike, but their diameters and sectional densities different. But on comparing the Martini-Henry with the small-bore 0·303″ magazine rifle bullet, in which not only the diameter is less, but the weight is also reduced, it is shown that the retardation which these two bullets would undergo would be rather greater for the magazine rifle projectile, viz., as 2·953 to 2·961, supposing them to be moving at the same rates of speed. Although, however, the opposition of the air would exert nearly the same retarding influence on the progress of these two projectiles, the higher muzzle velocity of the magazine rifle bullet gives it a flatter trajectory, and its other qualities confer on it greater penetrative energy over a greater distance than the Martini-Henry. When the two bullets have respectively reached ranges at which their velocities have become alike, then the less weight of the ·303 projectile will tell unfavourably for its power of overcoming resistance, and its velocity will be lost at a quicker rate than that of the Martini-Henry bullet will be. But as regards power of penetrating such structures as those of the human body, it is not improbable that the narrow and hard Lee-Metford projectile would still have an advantage over the Martini-Henry projectile.

(*e*.) **Component substance of projectiles.**—The materials of which projectiles are composed exert a considerable influence on the nature and characters of the wounds caused by them. This practically only refers to projectiles from small arms. If bullets of solid steel could have been employed with fire-arms, many of the ordinary features of gunshot wounds to which surgeons have been accustomed would have been changed. The increased hardness and cohesive force of the steel would have caused parts of accoutrements, and the strongest bones of the body, to be easily perforated by it. The steel bullet would not have been liable to become softened at ordinary increases of temperature, to be broken and dispersed in fragments, to be subject to partial loss of substance, or to undergo the various alterations in form which the leaden bullets were liable to on coming into collision with certain external objects and hard parts of the body.

A comparatively soft, inelastic, dense, and cheap metal, such as lead was, however, until recent years, alone seemed to answer the general purposes and various objects sought for by combatants in these implements of injury. It was necessary that the metal should be a yielding one, in order that it might be capable of expanding and of being compressed into the grooves of the

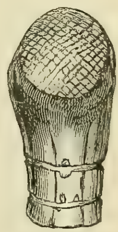
rifles; it had to be dense, so that it might present a considerable weight within a limited bulk; and it was required not to be costly, so that projectiles might be provided in sufficient number for the purposes of war. Lead best answered all these purposes.

A hardened alloy of tin and lead, as already mentioned, was used for the Martini-Henry projectiles, but though they were more elastic and had more power to overcome the resistance of an opposing substance than bullets of pure lead, their hardness was not so much increased in this mixture as to prevent the bullets from readily expanding when fired, and taking the grooves of the rifle. A Martini-Henry bullet can be readily indented by the thumb-nail, and nearly to the same depth as if it were a bullet of pure lead; and the marks of the rifling, after one of these bullets has been fired, are seen plainly upon its surface.

The drawing which follows (fig. 34) shows with what perfect definition the marks of an object, such even as the texture of canvas, against which a hardened Martini-Henry bullet has struck, may be impressed upon the metal under suitable conditions. The occurrence would be less worthy of remark if the bullet had been a soft leaden one.

Some Martini-Henry bullets were being fired at an ordinary canvas target. One of them failed to penetrate the canvas, and was picked up afterwards at the foot of the target. There was a strong wind at the time, and its direction was such that it caused the canvas to belly towards the bullet under notice. The canvas screen was a large one, about 6 feet × 6 feet, and its distance from the firing party was about 1600 yards. The remaining velocity of the bullet at the time it struck must have been about 500 foot-seconds, and its energy therefore about 260 foot-pounds.

Fig. 34.



Martini-Henry Bullet impressed by meshes of canvas.

Colonel W. Mackinnon, late Chief Instructor at the Hythe School of Musketry, who was superintending the practice, and who lent me the bullet for observation,[8] considered the only explanation of the occurrence to be that the force of the wind pressing on the whole surface of the back of the screen, and bellying the canvas outward toward the bullet, must have been such as to permit the canvas to distribute the blow over the whole body of the wind opposing it,—thus converting it into an exquisite spring capable of absorbing the blow without the canvas being penetrated.

Perhaps the obliquity with which the bullet at its angle of descent struck the canvas, should also be taken into account. The altered shape of the front of the bullet, where it was pressed down by the collision, shows the angle at which the bullet came into contact with the canvas. The bullet must have rebounded

at once after the blow; it did not glide along the canvas, or the marking would have been different. The crossing threads of the canvas are plainly impressed on the flattened surface. I have frequently seen similar impressions on leaden bullets, that have carried pieces of linen before them into the body. But in the present instance, the fact of a hardened bullet striking canvas, unsupported by any solid substance behind it, with such force as to lose shape and retain an impression of the texture of the cloth, while it failed to penetrate its fibre, is certainly remarkable. There is nothing unusual in the marks of the rifling upon the bullet; the impression of the rifling is always as distinct on the surface of a fired bullet, even in a modern armoured projectile, as it is in the sample under notice.

With the introduction of the small-bore rifle bullets homogeneity of substance has disappeared. Each of these projectiles is composed of at least two distinct and separate parts; one, an inner portion or core, the other an outer portion, the envelope or cover. The core of one of these compound bullets usually consists of compressed lead, or lead hardened by an admixture of antimony or tin; the envelope of some harder alloy or simple metal. In some instances the envelope has consisted of steel, in others of copper, in others again of metallic combinations, such as cupro-nickel or ferro-nickel. Maillechort, the envelope of the French Lebel and other rifle bullets, is composed of a combination of zinc, nickel, and copper. Whatever the nature of the envelope, however, it has to be sufficiently firm and resisting to withstand the enormous pressure of the gas concentrated upon it in a small-bore rifle, without any change being produced in the figure of the bullet, and therefore in the position of its centre of gravity.

The envelope does not cover the central portion of the base of the bullet, so that there is a more direct action of the gas resulting from explosion on the leaden core, and probably at the same time less tendency to laceration of the envelope, as the pressure on the lead is diffused evenly over its substance. At the same time the overlapping of the circumferential margin of the base by the envelope secures the core in position, and serves to prevent risk of separation of the envelope from it by the action of the gas at the time of discharge of the bullet from the rifle.

When the compound bullets were first subjected to trial, part of the leaden core was occasionally forced through the front of the envelope. Subsequently the fore part of the envelope, and the shoulder where it tapers off into the cylindrical portion, were made thicker and thus strengthened—ferruled—while the part covering the cylindrical portion was left in its previous condition. As it is essential that every rifle bullet shall be capable of undergoing sufficient expansion from the action of the exploded powder

to fill the grooves and follow the twist of the rifling, in order to prevent windage and to acquire its proper movement of rotation, it would not answer for the cylindrical portion, or, at any rate, its surface, to be of too unyielding a quality. Technical necessities, too, demand that the superficial hardness of the projectile shall be limited, not merely that it may 'take the rifling' of the weapon fully, but also that the edges of the grooves may not be too quickly worn down by friction during its passage. The marks of the grooves of the rifling are obvious to sight on examining one of the Lee-Metford bullets after it has been discharged from the rifle, but as the original grooves in the British magazine rifle are only ·004″ in depth, the slight interference with the smoothness of surface caused by them can scarcely affect the passage of the projectile through the air, or act as any impediment to its progress after penetration of an opposing substance. It will thus be seen that the material of which the exterior of one of these compound bullets is constituted is of a nature to increase the penetrating power of the projectile, and at the same time, as already referred to under the heading of 'Shape,' to prevent alteration of form, or distortion such as leaden bullets were liable to under the influence of heat and the opposition they might chance to meet with in the act of collision with resisting substances. The effect of the hardness of the envelope, in conjunction with the other qualities of the new rifle projectiles, in augmenting their penetrative energy, is well illustrated by the manner in which they overcome the resistance of water. Experiments show that when a leaden conoidal bullet is fired into water from a short distance in a direct line, so much opposition is made to its passage, that its front becomes compressed and flattened, and its progress speedily stopped; while under similar circumstances one of the new rifle bullets generally pursues its course without alteration of form, and prolongs it to a greater distance. In a similar manner the material employed for the envelopes of compound bullets has a share in influencing the characters of the wounds inflicted by them on human bodies.

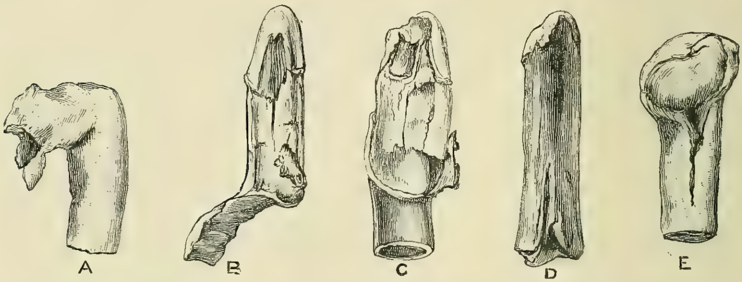
Collision of compound bullets at high speed with hard bodies.—When the Lee-Metford bullet, while still armed with a high rate of velocity, is brought into collision with a resisting substance, such as a piece of flint, the envelope is liable to be more or less torn from the core, and the core to be deformed.

The illustrations which follow, which have been sketched from some Lee-Metford bullets that had accidentally struck stones on the ground before reaching the butts at Bisley, and which had been picked up at random, will sufficiently show what complexity of deformation the detachment of the thin but hard metal cover from the leaden interior may cause, and from them may be inferred what lacerated openings, and relatively wide

and jagged tracks, wounds inflicted by bullets so deformed may present.

In fig. (*a*) the cupro-nickel envelope has been completely removed and the leaden core at its apex spread out irregularly, torn and bent back; in (*b*) nearly all the envelope has been cleared away, only a small thimble in front being retained, while the core is much distorted; in (*c*) the entire bullet is slightly curved, while a great part of the envelope is detached from the lead, but still retains connection with it; in (*d*) the projectile is flattened laterally, furrowed, pressed back at the apex, and is rent open at the base; in (*e*) the whole apex is squeezed back, the lead exposed and

Fig. 35.



(*a* (*b*) (*c*) (*d*) (*e*) Effects on Lee-Metford Bullets of collision with stones before reaching the target against which they were aimed. Target at 200 yards.

bulged, while the envelope is split open nearly to the base. It is evident that the alterations in form which may occur under similar circumstances may be almost infinitely varied.

That corresponding deformations may occasionally, though in all probability rarely, occur when narrow armoured bullets are brought into collision with the bones of the human body, is shown by the following illustrations of the effects of such collisions observed in certain experimental trials made on cadavers at Frankford arsenal in Pennsylvania. They are copied from the official report of the Surgeon-General, Washington, for the year 1893. The projectile shown in the illustrations was fired from a rifle of ·30-inch calibre, was 220 grains in weight, had an initial velocity of 2000 foot-seconds, and was composed of a core of compressed lead within an envelope of German silver. After passing through the cadavers the bullets were caught in sawdust placed behind them. The charge employed consisted of 70 grains of black gunpowder.

The following descriptions are taken from the report in which the drawings originally appeared.

No. 1. (*a*) The core separated from the envelope and badly mushroomed; (*b*) fragment of the envelope, the only one recovered. The bullet was fired into an arm at 17 yards' distance, with a full charge of powder. The humerus was pulverised 3 inches in extent, and the soft parts showed wide explosive effects.

No. 2. Core of ·30-inch calibre German silver jacketed projectile, showing deformation after causing extensive comminution of the femur when propelled with the velocity remaining at 500 yards' distance. The core alone was recovered.

No. 3. A similar projectile deformed after perforating the

FIG. 36.

Deformations of Armoured Rifle Bullets, ·300″ in diameter, after collision with bones of human cadavers. (Description in text.)

lower shaft of the femur at 2000 yards. The core (*a*) had escaped from the envelope (*b*) through a rent in the conical end. The concavity in the core probably resulted from it colliding with another projectile in the sawdust.

The following illustration, fig. 37, is of particular interest, inasmuch as the surface from which the bullet ricochetted was described as being 'very soft ground,' and the distance at which it rebounded from the ground was 1000 yards from the point at which the rifle was fired.

FIG. 37.

Lee-Metford Bullet deformed on striking very soft ground.

In order to ascertain whether the core and its cover would be flattened together, or remain in combination if broken up into fragments, on the Lee-Metford bullets being fired directly against a hard substance, I got some of these projectiles fired against an iron target at 200 yards' distance. In none of the instances I examined did the cover and core, or any portions of them, remain together after the collision. In one instance the whole cupro-nickel envelope was completely removed, and flattened out with jagged sharp edges, no particle of the leaden core remaining attached to it. In another, the envelope was torn off, twisted, and doubled upon itself, but retaining the circular rim

which had surrounded the base of the bullet in its original shape. The leaden cores were broken up into thin plates of lead of all shapes and sizes. Among them were small fragments of the cupro-nickel covers, but in every instance the detachment of the cover from the lead was complete. I have not had the opportunity of ascertaining whether, under the same circumstances, a similar separation would take place, if the envelopes were made of steel instead of cupro-nickel. Experiments made on the Continent with steel-mantled bullets appear to show that they are not subject in the same degree to deformation as bullets with envelopes of the compound metals in general use. If experience should lead to the general adoption of steel for the covers of small-bore bullets, the change would probably have an important influence on the characters of many of the wounds liable to be inflicted by them, for there would be a greater proportion of clean perforations, and extensive splintering might be expected to be more rarely witnessed.

(*f.*) **Density of projectiles.**—The experiments showing the greatly increased power of penetration obtained by hardening the bullet of the Martini-Henry rifle with tin, as compared with the penetrative power of the leaden Enfield rifle bullet, have already been noticed. This gain in penetrative power of the Martini-Henry bullet is due to its relative hardness, diminished diameter, and its other qualities, but not to any increase of density consequent on the combination of the two metals, or in other words, what nearly amounts to the same thing, to increased weight while the volume or bulk remains unchanged. In the pursuit of wild and savage game, sportsmen have remarked that greater disabling wounds have been inflicted by mixing the lead of bullets with quicksilver than by mixing them with tin, owing to the superior density obtained by the former combination. An alloy of tin and lead undergoes expansion, and the density is less than that of pure lead in proportion to the amount of tin which enters into its composition; the alloy of mercury and lead undergoes contraction, and the density is considerably greater than that of lead alone. Increased density in the material of which a projectile of a given diameter and bulk is composed, will give increased power of maintaining velocity during its flight, and increased penetrative power, as explained under *sectional density*, but will not make much difference in the characters of a wound inflicted by it, when compared with one made by a bullet of similar size, shape, and velocity. Substances of very low degrees of density, such as plugs of tallow, wads of paper, and others, are able to inflict penetrating wounds in the softer structures of the body, having most of the characters of wounds produced by denser projectiles, if sufficient velocity be impressed

upon them. But the necessary force to accomplish this result can only be exerted within very limited distances, for the resistance of the air acting on such bodies as these rapidly retards their progress and soon destroys their force.

CHAPTER II

CONTINUATION OF THE SUBJECT OF THE CONDITIONS APPERTAINING TO PROJECTILES BY WHICH GUNSHOT INJURIES ARE MODIFIED IN THEIR PRIMARY CHARACTERS AND DEGREES OF GRAVITY

2. *Qualities impressed on Gunshot Projectiles by the Fire-arms from which they are Discharged.*

(*a.*) **Velocity of projectiles.**—The rate of the velocity[9] of translation or progressive motion possessed by projectiles must always be a very important, and in many respects the most important ingredient for the consideration of surgeons in the study of the wounds produced by them. The velocity imparted to missiles discharged from the fire-arms of early times—owing to the imperfect construction of the weapons, defective quality of the gunpowder, and other disturbing circumstances,—was probably as inferior to that of the musket bullets in use until comparatively few years ago, as the velocity of those musket balls was to the velocity and rates of progression of the conoidal rifle bullets which followed them, and was, of course, vastly lower in degree than the rates of initial and sustained velocity impressed on the small-bore projectiles of the present day. In a table showing the velocities of certain moving bodies, published a few years before the Crimean War, the common musket ball was set down as moving at an average rate of 850 miles per hour; the 2-grooved rifle ball, which was the arm at that time of the Rifle Brigade, at 1000 miles; the 24-lb. cannon ball at 1600 miles per hour. Statements of averages such as these were of no practical value, for, of course, the true rate of motion of any particular projectile must be constantly varying during the whole range of its flight. The velocity diminishes from the moment the projectile quits the gun, when the velocity is at its highest intensity, to the moment its course is finished. But using the statement merely for purposes of comparison, it may be recalled to mind that at the time it was made the musket bullet could not be depended on to hit an object beyond 80 yards, the rifle bullet from 200 to 250 yards, while modern rifles are sighted for striking objects to 2000 yards, and even farther.

Initial velocity of translation.—The velocity of a spherical

bullet at its first quitting the barrel of a fire-arm, or its muzzle velocity as it is often called, when discharged from a smooth-bore weapon, such as the old musket was, if the ball were so well fitted that windage was prevented (which practically scarcely ever, if ever, happened in warfare), would be really greater than the initial velocity of an elongated bullet of like weight from a grooved rifle, propelled by a like charge of gunpowder. There are not the friction and expenditure of power in the smooth-bore barrel which there must be in the grooved rifle in forcing the bullet to follow the spiral direction of the grooves on its inner surface. But when once the two kinds of projectile are free from their respective weapons, so great a resistance is offered by the atmosphere to the passage through it of the relatively large-fronted spherical projectile, compared with what is offered to the prolonged cylindro-conoidal bullet, with its diminished and shelving frontage, that the power of the spherical projectile is altogether lost at a distance at which the conoidal bullet is in nearly as full force as when it first quitted the muzzle of the rifle. The rifle bullet can never gain any increase of velocity, and therefore of power, over that which was first impressed upon it; but it parts with that force very much less quickly than the spherical bullet, because the air has less retarding effect upon it. It is therefore evident that, in general, as regards wounds inflicted in warfare, the initial velocity is mainly of interest to surgeons, inasmuch as it determines the rates of velocity which the projectile may, subject to other circumstances, possess subsequently; it is the velocity which is preserved by the bullet at different distances in the course of its flight, especially when its flight is very prolonged, that chiefly affects the characters of the polemical wounds which military surgeons are called upon to treat.

In particular cases, however, in which the wounds were inflicted by the old spherical bullets discharged from muskets at very short distances, it became necessary to take into account the initial velocity of the projectiles in order to explain the destructive effects which were witnessed from their action. During the last war in New Zealand a large proportion of the wounds inflicted on the British troops were from smooth-bore musket projectiles fired at very short ranges, often from rifle-pits close at hand, and the destruction effected on the bones was great in proportion. Some surgeons, seeing the enormous amount of injury done by these spherical bullets in a few particular instances, were led to express an opinion that the general belief in conical bullets possessing more destructive power in warfare than the old round bullets was founded on error. But in coming to this conclusion, they had omitted to take into account the great initial velocity of the bullets from the smooth-bore weapons, and, as a necessary result, the great power of destruction belonging to them near to the fire-arm. At a

distance of 100 or 150 yards the spherical bullets would have lost their wounding power, while the elongated rifle bullets at those distances would have lost scarcely any of their original force. Other qualities belonging to the spherical bullets, which are elsewhere described, would join with their early velocity in producing a large amount of local damage on being brought into collision with bone, but these qualities would be of no avail without the high velocity.

The attainment of two ends appears to have been mainly kept in view in the alterations which have been made of late years for combatant purposes in portable fire-arms and their projectiles. These have been—(1) to increase the initial velocity both of translation and rotation; (2) to prevent as far as possible these velocities from being retarded after the bullet has left the fire-arm until the time when it strikes the object aimed at. To attain the former of these objects, successive improvements have been made in the construction of the fire-arm and in the propellant powder; to attain the latter, improvements in the forms, dimensions, and other qualities of the projectiles. Other purposes which more particularly concern combatants have doubtless at the same time been kept in view, but those above named have outweighed all others in importance from the surgeon's point of view. The results of the efforts made in the two directions mentioned have been very successful in adding to the force and extending the range of rifle projectiles, and are of great interest to surgeons in respect to their wounding effects at different distances. The increase in initial velocity effected in three of the more recent British rifles alone needs to be alluded to here. All these rifles are in the hands of some of the imperial military forces either at home or abroad, viz., the Enfield, the Martini-Henry, and the magazine rifles.

With regard to the bullet of the Enfield rifle in its latest form, the Snider-converted Enfield rifle, the initial velocity was raised to 1240 feet per second; that of the bullet of the Martini-Henry rifle, which succeeded the Enfield, to 1315 feet per second; while that of the new magazine rifle bullet is 1800 to 1850 feet per second with ordinary gunpowder, and 2000 feet per second with cordite powder. This weapon was sighted for an initial velocity of 2250 feet per second, and it is not improbable this velocity will be attained if the chemical explosive applied to the weapon should be brought to a higher state of perfection. A muzzle velocity of 2500 or 2600 feet in a second, or even higher, has been considered likely to be attainable without lessening the efficiency of the rifle as a weapon in other respects.[10]

Causes by which Velocity of Translation is Retarded.

It is especially the opposition of the air through which a bullet has to force its way onwards before striking any object it

may be aimed at that causes a continually progressive diminution of its velocity. The mass of the projectile and the attraction of gravitation to which it is subjected, or, in other words, its weight, the form of the bullet, especially of its front, the condition of its surface, its volume, various states of the air itself, the force and direction of wind, all affect the ease and rapidity with which the atmospheric particles are displaced by the projectile, and consequently the rate at which the speed of its flight is retarded. Equally the amount of the velocity impressed upon it when it first left the fire-arm which remains at any given point in its course where its further progress may be suddenly arrested, will depend upon the same causes. If the initial velocity and the rate of retardation of a rifle bullet of given weight and diameter be known, the remaining velocity at any given distance from the fire-arm will admit of ready calculation.

The following have been given as the rates at which the velocity of the Martini-Henry bullet becomes lessened in proportion to distance in consequence of the resistance of the air alone. Starting with an average muzzle velocity of 1315 feet per second, its speed at 500 yards is lessened to 869 feet per second, at 1000 yards to 664, at 1500 yards to 508, at 2000 to 389, at 2500 to 301, and at 3000 yards to 283 feet per second.

The effect of the resistance of the air is similarly shown by the increase in time taken by the bullet to travel over equal distances in its path in proportion as its range is advanced. Thus while the Martini-Henry bullet travels over its first 500 yards in 1·4 second, it takes 1·9 second to accomplish its second 500 yards, 2·3 seconds its third 500 yards, 2·9 seconds its fourth, 4 seconds its fifth, and 6·8 seconds to pass along its sixth 500 yards. So it reaches a point at 500 yards' distance from the muzzle of the rifle in 1·4 second, at 1000 yards in 3·3 seconds, at 1500 yards in 5·6 seconds, at 2000 in 8·5, at 2500 in 12·5, and only reaches a distance of 3000 yards in 19·3 seconds of time. If the bullet were to move uniformly at the same rate as it passed over the first 500 yards of its path, it would of course have reached the 3000 yards' distance in 8·4 seconds.

Influence of velocity on destructive power of bullets.—The increase in power of overcoming resistance, and therefore in wounding power, brought about by increased velocity, is very great. Whatever might have been the destructive energy possessed by a bullet travelling at the rate that one of the old spherical bullets from the smooth-bore musket travelled at after it had arrived at a distance of 70 or 80 yards from the fire-arm, another bullet of similar form and equal weight, but travelling at double the rate of speed, at the same distance would have had its power increased, not twice, but fourfold. The rule is, that if the velocity of a bullet be increased, its power of overcoming opposi-

tion will be augmented proportionably with the square of the increase in velocity. If at any given distance a rifle bullet travel at ten times the rate of speed of a spherical bullet of the same weight, then, from that cause alone, without estimating the effects of its different shape or of any other peculiar qualities it may possess, its energy or mechanical power will be increased 100 times. 'If,' writes Professor Tyndal, 'you double the velocity of a cannon ball, you quadruple its mechanical power. The measure, then, of mechanical power is the mass of the body multiplied by the square of its velocity.' And it is added in the Manual of the School of Musketry, from which this quotation is taken:[11] 'Thus if the velocity of any number of shot of a given weight at any particular distance be known, their comparative powers of inflicting mischief at that distance are also known.' (Treatise on Military Small Arms and Ammunition, compiled at the School of Musketry, 1888.)

When the obtuse and comparatively soft spherical leaden bullets were in general use, their power of penetrating the body altogether depended upon the degree of onward velocity which they possessed at the time of being brought into collision with the persons struck by them. Their form was very unfavourable for penetration of the skin and subjacent tough and elastic tissues of the body. So also, on penetration being effected, the distance to which a projectile made its way was more completely dependent upon its velocity than is the distance to which modern bullets, especially bullets of very narrow diameters, penetrate. A certain amount of velocity is of course essential for penetration in all bullets, but with an elongated cylindro-conoidal bullet the great velocity it maintains over a very long range is joined with better adaptation of form, with greater density and hardness, and with a very rapid spinning rotation of the projectile on its long axis, all of which are favourable for penetration of the tissues, even the hardest, of the body. With the spherical bullets not only was great velocity necessary to give them the power of penetrating the surface of the body, but from their obtuse hemispherical frontage and the size of their equatorial area, this velocity was more easily and more speedily retarded by the opposition of the tissues which they had to push before them, or by the resistance of the several layers of yielding and elastic structures through which the projectiles had to make their passage. Even in passing through such soft and yielding tissues as the flesh of one of the extremities, the velocity became so retarded that, as a consequence, the condition in which the parts were left at the place through which the ball passed out differed considerably from the condition of the tissues through which it had first effected its entrance. In penetrating bone, especially the spongy portions of bones, unless the rate of velocity were unusually high, the cancellated structure,

which was crushed up and massed before it, generally offered sufficient resistance not only to retard, but to arrest altogether the progress of the projectile, and thus to lead to its lodgment. The elasticity of certain tissues, such as the skin, tendons, and ligaments, constantly led to a stoppage of the further progress of the bullet, when the velocity of the spherical projectile had become reduced by the opposition it had met with from the structures through which it passed before reaching them.

Hunter's remarks on some of the effects of velocity, and especially as to gunshot wounds healing by first intention.— John Hunter, after describing that in gunshot wounds parts of the solids surrounding the wound are deadened and have afterwards to be thrown off in the form of a slough, adds: 'This does not always take place equally in every gunshot wound, nor in every part of the same wound; and the difference commonly arises from the variety in the velocity of the body projected, for we find in many cases where the ball has passed with little velocity, which is often the case with balls even at their entrance, but most commonly at the part last wounded by the ball, that the wounds are often healed by the first intention.' [12]

It is very difficult to explain this expression of John Hunter, that the velocity of a spherical bullet may be so diminished as to lead to a wound inflicted by it, especially the opening of entrance, healing by the first intention. I have never seen a musket bullet wound heal by the first intention myself, nor have any English surgeons of experience in such matters whom I have consulted on the point seen such an occurrence. Probably Hunter alludes to instances in which a musket bullet has seemed to have torn asunder the tissues at the wound of exit without crushing or even contusing them, leaving a truly lacerated wound; for under such circumstances primary adhesion, or, at least, very early union, would sometimes occur. Or occasionally where a splinter of bone had been driven through part of the surface of a limb, and an opening had thus been made through which the bullet escaped, very early union, without suppuration, might occur. Not so, however, at the opening through which a bullet had forced admission. An obtuse body, such as a musket bullet, especially one of the size, shape, and weight used with the old musket, could not force an entrance into the structures composing a fleshy part of the body, or effect a passage through them, without possessing such a degree of velocity as would inevitably cause it to do serious damage to the tissues traversed by it, leaving at the same time a gap in them that could only be filled up and healed by a process of more or less effusion and granulation. Moreover, the passage of such an obtuse bullet through the soft tissues of the body is attended with other circumstances, elsewhere described, besides those which depend upon the rate of velocity with which the passage is effected,

which militate against primary healing, either by immediate union or by primary adhesion.[13]

Influence of velocity in fractures of bones.—I mentioned the splitting effects of conical bullets on the shafts of the long bones of the extremities when referring to the peculiarities of their shape. But the amount of velocity, I need hardly observe, is an essential ingredient in estimating this result. The spherical bullets, from their lower rates of speed, on striking bones might simply be turned away from the direct line with some flattening of their surfaces; or having perforated, might remain in the cancellated structure, or might knock out a portion or portions of the shaft, often without any such violent dispersion of the fragments among the surrounding soft tissues as to interfere with the processes of repair, and without much splintering of the bone beyond the seat of fracture. Such mild effects as these have been seldom seen when the injuries have been inflicted by rifle projectiles; probably never, unless their speed has been so reduced by distance of flight, or by accidental circumstances, that they have been brought to an equality with the old musket bullets in respect to their rate of velocity.

Velocity of secondary projectiles.—The rate of velocity of secondary projectiles of irregular forms, such as fragments of hollow shells deriving their impulse from internally applied forces, or substances struck and propelled by shot, varies according to many circumstances, but is always less than would be that of direct missiles of regular forms and similar weights at corresponding distances from the original source of impulse. Their power of inflicting injury follows the general rule expressed by the formula $\frac{MV^2}{2}$, but their power of penetrating the body is affected by different conditions. The inconstant characters in respect to mass and shape of such secondary projectiles as splinters of wood and iron, stones driven by shot from parapets, and many other such missiles, cause the wounds inflicted by them to differ from each other individually in their appearances, no less than they differ in their general characters, from those inflicted by primary missiles of systematic shape. A fragment of a shell by which an opposing body happens to be struck may present a front to the part with which it has come into collision which is either convex, concave, or flat, or an edge which is either smooth, pointed, or jagged, according to the manner in which the shell has been rent asunder, and the direction maintained by the fragment at the moment of its impact. Whichever of these aspects the fragment may present, the resistance offered by the air to its passage is usually so great, that whatever may have been the velocity it started with, it becomes quickly retarded, and consequently its destructive force proportionally lessened.

The diminished force of the stroke of these secondary missiles is not merely due to the fact that they have received their impulse second-hand, when the results of the original impulse have been partly expended in the flight of the primary projectiles, but is also attributable to a further diminution of the force remaining in the primary projectiles in consequence of the amount of resistance which has been offered to them in the act of displacing the secondary ones. Whether they are the fragments of a hollow shell that has been rent asunder by the disruptive force of a bursting charge, or they are fragments forcibly torn away from some resisting object, either wood or stone, the force expended in effecting the disruption is so much force lost as regards the propellant energy of the resulting missiles. Thus they start with a relatively low rate of velocity, and this is rapidly retarded by the resistance of the air to their progressive movement. At comparatively short distances from the point of departure, the velocity of such secondary missiles is often so reduced that we find them merely inflicting contusions, or if the resistance of bone is offered to their further progress, simple fractures resulting, when from direct projectiles the fractures would have been almost necessarily compound ones.

The velocity, and consequently the destructive force, of fragments of shells will, however, greatly depend upon the circumstances under which the shells are exploded. When they fall and rest on the ground and are then exploded, the velocity imparted to the fragments depends solely on the nature and amount, or, in other words, the propelling force of the bursting charge. The velocity thus imparted, when the bursting charge consists of gunpowder, is sufficient to give the iron fragments force enough to inflict very grave wounds within limited distances; but owing to circumstances already referred to—their flattened and irregular forms, and the resistance of the air to their passage, together with the effects of their own weight, or, in other words, of the force of gravitation—the velocity is so rapidly retarded that the fragments only rise to comparatively moderate heights, and fall within relatively short distances. If the bursting charge consist of one of the new high explosives, the propulsion impressed on the fragments will be all the more violent, and they will be scattered while possessing such increased velocity, that not only their penetrative energy, but also the extent of area over which they may exert their destructive power, will be immensely increased. It is stated that one of the modern French shells, with a bursting charge of melinite, is broken up into an immense number of fragments, and that the starting velocity of these fragments is so great that some of them are found at a distance of 300 metres, about 328 yards, behind, and of 900 metres, about 984 yards, in front of the focus of explosion. Within a radius of 50 metres, men and horses would

be riddled and destroyed by the explosion of one of these melinite shells. When the shells burst while moving onwards with great progressive force, as may happen with shrapnell shells, then the fragments for a short time retain a great part of the velocity by which the entire shell was animated at the time it was broken asunder, and they strike with immense force. This velocity, however, is quickly retarded by causes before mentioned. When shells, on the other hand, are projected upwards and burst at great heights in the air, then the fragments gain a constantly accelerated rate of velocity according to the height from which they descend, or, in other words, according to the time they are subjected to the influence of gravitation, modified, however, by the retardation due to the resistance of the air in their fall—a resistance which is rendered very obvious to the sense of hearing by the loud peculiar whistling noise which accompanies their descent. The final velocity under such circumstances is so great that the shell fragments when large strike with overpowering force, and cause proportionate destruction of all the tissues with which they may happen to be brought into collision.

Velocity of falling bullets which have been fired directly upwards, or nearly directly upwards.—Small rifle projectiles fired upwards into the air acquire so great a velocity in descending, that if they happen to fall on the head or upper part of the body of a person, they usually produce immediately fatal results. From the suddenness of the event, the absence of warning, occasionally no weapon or smoke being seen, no noise of discharge heard, such a mortal wound has a peculiarly appalling effect. During the siege of Sebastopol some cases occurred in which men were sitting in the trenches with their backs leaning against the parapet, protected from injury by direct shot, yet in this position were killed by bullets falling from above. In one instance a bullet completely perforated the trunk of the soldier; it entered at the shoulder, traversed through the chest, abdomen, and pelvis, and then passed into the ground. The rifle from which it had been fired must have been pointed at a very slight inclination away from a straight direction upward, and the shot, at the time of striking the man, was armed with nearly as much destructive power as if it had just left the weapon. In December 1859 a case which occurred in the Governor-General's camp in India attracted considerable notice. A native servant was cleaning his utensils after dinner, when, without a sound being heard, he fell dead. Surgeon, now Sir William Mackinnon, who was in medical charge of the Head-quarter Staff, was informed of the circumstance, and went and examined the man's body. He found on the outside of the deltoid muscle of the left arm a small perforating wound, and just at the lower edge of the great pectoral muscle another small valve-like opening, such as might have been made by the intro-

duction of a knife. Suspicion was at first excited that the man had been stabbed. On further examination a slight emphysematous crackling sensation was noticed just above this opening, and Surgeon Mackinnon, on introducing his little finger, came to a rough edge of bone. This was cut down upon with a scalpel, and a hole was found punched completely through a rib, a thin edge above and a thin edge below being left. The piece of bone had been carried through into the chest. The chest was afterwards opened, and wounds discovered through the lung, through both ventricles, and through the diaphragm. A furrowed mark was noticed on the under surface of the liver, and finally a bullet was found lodged in the right iliacus muscle—the opposite side of the body to that at which it had entered. The bullet had evidently been fired upwards into the air by some one a long way off from the man whom it happened to hit in its fall.[14]

Shot, the velocity of which is nearly expended, or 'spent shot.'—When the velocity of a direct projectile is diminished below a certain rate of movement, it is ordinarily spoken of as a *spent shot* or a *spent bullet;* and before leaving the subject of the effects of velocity impressed on projectiles, a few words are necessary with regard to the power of destruction possessed by the larger forms of these spent shot. Some of the effects of diminished velocity in the smaller forms of shot will be considered when making remarks upon the subject of 'Lodgment of bullets.'

In the days when solid spherical gunshot were in use, on one of these projectiles ceasing to pursue its course through the air, or to proceed by ricochet, it not unfrequently happened that it would travel to a considerable distance, rolling along the surface of a level piece of ground. When its rate of movement was not much faster than that at which a man could easily walk, and when, to all appearance, the projectile might be stopped by the pressure of the foot as readily as a cricket-ball near the end of its course, it still possessed the power of inflicting serious injury if such an attempt were put into execution. This power will be easily understood by any one who considers the amount of progressive force which there must still be in the shot to enable it to move forward in spite of the weight of its mass, and the resistance from friction to which it is subjected in passing over the ground on which it is rolling. Its velocity, slight though it may be, squared and multiplied by the mass of the shot, represents its destructive power. If a solid shot of the kind mentioned were brought into collision with the foot of a person, such destruction would usually ensue as to necessitate amputation. Should it impinge on other parts of the body, as in the instance of a man lying on the ground, it would not improbably cause mortal injury to internal organs; and so, also, though no longer having power enough to completely carry off a limb, it would almost certainly cause com-

minuted fractures of the bones and extensive contusions of the softer structures covering them. Occasionally a simple fracture might result from a spent gunshot, but such an accident was very rare.[15]

Accidents used to occur not unfrequently from spent gunshot in the early periods of campaigns and sieges, before the soldiers who were unaccustomed to active service in the field had become acquainted with their qualities. Mr. Cole has related the case of a boy whose thigh he had to amputate near the hip-joint for a laceration involving the femoral vessels from a 6-pounder shot at the siege of Mooltan. In this instance, the boy, who recovered, declared that the shot had not come to him, but that he had seen the shot rolling, and that it appeared to him to have stopped at the time he stooped to pick it up. When the regiment I served with first took up its position on the right attack before Sebastopol, before the siege opened, several heavy round shot fell on different occasions within our lines. One of these dropped near my tent and half-buried itself at the end of a very shallow, slanting depression, which its weight and the direction in which it had been projected caused it to make in the ground. While its farther onward progress was stopped by the earth it had squeezed up at the deeper end of the groove it had thus made, it continued for some time slowly turning round and round as it lay in its bed. This movement of rotation continued after all effort at a forward movement appeared to have ceased. Several soldiers who had been attracted by the rushing noise of its fall had run towards the spot where the shot alighted, and one of these men was in the act of stooping down for the purpose of picking it up, when, fortunately for himself, he was pulled back by an older soldier, in time to prevent him from reaching it. Had he laid hold of the revolving shot, he would no doubt have paid the penalty of the loss of his hand for his rashness. The force remaining in the ball was sufficiently evidenced by the continued rotation of so weighty a mass. On the other hand, to mention an example of coolness resulting from familiarity with the qualities of such projectiles, at a later period of the siege I happened to be near a French covering party who were returning from the trenches, when the spurts of dust rising from the ground between us and the enemy's works attracted the attention of some of the men to a round shot which was ricocheting in our direction. The ball ceased to bound at a moderate distance off, and then came rolling along up some rather sloping ground, which the covering party had just passed over. It soon reached the spot where we then were, rolled along through the party, and pursued its course for a considerable distance on in front of us. The rate of its movement was slow enough for some of the men in front to be put on their guard by the men in rear calling out to them, so that, one after another, they stepped on either side, making a lane, as it were,

for the ball to pass through. There were plenty of jokes addressed to the shot by the soldiers as it passed among them, but there was no one who was not then fully alive to the necessity of making no attempt to interfere with its progress, though to the eye it seemed as if it could have been arrested in its course with the greatest ease.

M. Baudens has related a case which strikingly illustrates how extremely small an amount of progressive motion remaining in a heavy shot may suffice to enable it to inflict a fatal injury. A soldier in the Crimea, sleeping on the ground, was struck by a spent gunshot, and was instantly killed. He had been lying on his side, and the ball had rolled against him and dislocated his spine. Yet so little power of movement was there in the shot at the time, that it remained stationary with the man whom it had killed: it was found in the hood of the unfortunate fellow's great-coat. In this instance it was evident that, had the man been lying only a few feet farther off, the projectile would not have had force enough to have reached him at all; it would have stopped spontaneously from its *vis viva* being exhausted.[16]

Injuries from spent gunshot, though not uncommon when round shot were in general use, have become comparatively rare since elongated gunshot with projecting studs have been introduced. Such projectiles can only travel along the ground when still armed with considerable velocity. Whether travelling front forwards in a direct line, or rolling round their principal axis, when their velocity is much reduced, the opposition from friction caused by the studs quickly arrests their farther progress. Still, toward the close of their course, and so long as any progressive or rotatory movement is retained by the shot, they have the same destructive power as spent shot of the old forms.

(*b.*) **Rotation of projectiles.**—The rotatory motion impressed on projectiles interests surgeons only so far as the missiles used with portable fire-arms are concerned. In them the influence of this quality is important, both as regards the production and also the course of wounds. The difference in the kind of rotatory motion imparted to rifle bullets from that which was impressed on the projectiles used with smooth-bore muskets has not a greater effect in correcting irregularities of flight, and thereby in meeting the requirements of combatant officers, than it has in producing results which demand the attention of medical officers. To estimate properly the influence alluded to, it is necessary to understand the difference between the revolving movement of a spherical bullet fired from a smooth-bore fire-arm and that imparted to a cylindro-conoidal bullet from a rifled weapon.

Rotation of spherical projectiles.—When a spherical bullet is fired from a smooth-bore weapon, owing to windage, from the bullet not being originally made to fit the bore accurately, or from the barrel becoming expanded by heat, the projectile while passing

along the fire-arm does not maintain an even, constant contact with the whole surface of the bore, but presses against it at certain spots more than at others. Whatever portion of the inner surface of the cylinder the bullet is last forced against as it quits the muzzle of the weapon, it acquires a rotatory movement towards that side; for, being momentarily held, as it were, at that point, the escaping gas exerts a more active progressive force upon the opposite portion of the bullet, where it is not in contact with the barrel. Two movements are therefore impressed on the projectile: a revolving one, or movement of rotation, and a forward one, or movement of translation.

Another cause of a revolving motion being communicated to a spherical bullet is met with when the centre of gravity of the projectile does not correspond with the centre of its figure. This discrepancy constantly happened when bullets were cast in moulds, and when an even density was not maintained throughout their whole substance, owing to the accidental presence of minute bubbles of air, or to the expanded melted lead having been cooled more rapidly on the outside, and so having led to a difference of consistence or small vacuum somewhere in the interior. If the centre of form and centre of gravity happened to coincide, the pressure of the volume of exploded gunpowder would be exerted equally upon the whole bullet, provided it fitted the fire-arm closely, and would then only communicate progressive motion to it; but if the centre of gravity should not have the same relation in respect to distance from the inner surface of the cylinder of the fire-arm as the centre of form, even though the bullet fitted the bore, the force would be exerted unevenly. In this latter case, so far as the particles composing the bullet would be concerned, a greater amount of force would be exerted on the half of the bullet on one side of the centre of gravity than on the half on the other side, and in consequence a revolving motion in addition to the progressive motion would be impressed on it. The revolving motion would take place round an axis passing through the centre of gravity of the bullet.

As the rotatory motion is continued in addition to the progressive motion throughout the flight of the bullet, and as the resistance of the air is greatest against that side of the bullet which revolves towards it as it flies onward, a certain amount of deflection in its line of flight must follow. This deflection is a serious matter from a combatant view, as it tends to cause failure in hitting any particular object which may be aimed at, but it is not of much moment in a surgical aspect, or is not of so much moment as is the particular direction which the rotatory motion follows relatively to the progressive motion.

Rotation of rifle projectiles.—From the foregoing description of the rotatory motion of spherical projectiles, it is evident that, whatever may be the part of the muzzle of the gun last touched by the bullet, or whatever may be the position of the centre of

gravity in regard to the centre of form, the rotation of the bullet will be always such that a line representing the axis on which the bullet revolves must cross, or be at right angles with, another line representing the line of its progressive motion. Whether the bullet be caused to whirl from right to left, or from left to right, or from above to below, the line of the axis of revolution will equally cross at right angles the line of onward movement of the bullet through the air. Not such, however, is the axis of revolution when the bullet is a cylindro-conoidal one, and projected from a modern rifled weapon. Here the spiral rifling of the weapon, together with the physical qualities of the projectile which enable it to be sufficiently expanded for its surface to be pressed into the grooves of the rifling, without alteration of its general form, cause the bullet to be brought into perfect contact with the whole interior of the barrel; the bullet fills up the bore together with the grooves; and at the same time, the rifling, by its spiral twist, impresses upon the bullet a rotatory motion in an exactly opposite direction to that just ascribed to the spherical bullets. The rifle bullet is caused to turn round on its long axis, which coincides with the axis of the barrel, as it is driven forwards towards the muzzle, and this same kind of rotation is necessarily continued after it quits the weapon. The axis of revolution of the cylindro-conoidal bullet as it flies through the air, instead of being across the line of flight, as it is in the spherical bullet, is therefore coincident with its line of flight. The spherical bullet turns like a billiard ball spinning across the table; the conoidal rifle bullet turns like a screw entering a piece of wood. The number of revolutions on its long axis made by an Enfield bullet at the moment of quitting the muzzle of the fire-arm was 194 per second, or, supposing the velocity to be uniform, 11,640 per minute; its progressive motion at the same instant being at the rate of 1265 feet per second; the number of revolutions of the Martini-Henry bullet, 787 in a second of time, or 47,220 in a minute, on quitting the muzzle of the rifle, and its initial velocity of translation, 1443 feet in a second; the velocity of rotation of the ·303 magazine rifle bullet when it starts from the muzzle, with an initial velocity of translation of 1850 feet per second, amounts to 2220 revolutions per second, or, supposing its velocities to be maintained uniform, to 133,200 revolutions per minute. If the muzzle velocity of translation be raised to 2000 feet per second, as it is when cordite is used as the explosive, the velocity of rotation is at the same time increased to 2400 revolutions per second, or at the rate of 144,000 turns per minute.

The purpose of the combatant officer in thus substituting a determinate for an accidental course of rotation is to maintain the stability of the bullet in its flight on the same principle that a top is kept upright while its spinning motion is sufficiently active.

The movement of rotation, or spin, of the projectile causes it to resist any tendency that may arise to a change of the axis on which it is rotating, as from the tilting action of the air during its flight, for example. In other words, the spinning motion tends to keep the long axis of the bullet always in the same direction, and the greater the rapidity of the rotatory movement, the greater will be the rigidity of the projectile, and the precision with which the direction of its long axis will be maintained, Hence, to the combatant the rapid revolution of the cylindro-conoidal bullet on its long axis assists in ensuring steadiness of flight and the acquisition of the means of hitting with more certainty the object or particular point of it against which his aim may be directed; it is the surgeon's part to observe the effects when the objects aimed at are men, and the missiles have reached their destination. These results may be best considered under (*a*) 'Effects on penetration;' (*b*) 'Effects on course after penetration.'

Effects of rotation on penetration of projectiles.—One of the direct effects of the axis of rotatory movement of spherical bullets not agreeing with the axis of their progressive movement was to lessen the number of chances of their penetrating the persons of men who happened to be struck by them, when compared with the chances of penetration there would have been if the progressive movement had existed alone. The effect of these movements being axially coincident, is to facilitate penetration. The generally rounded contour of the principal parts of the human body must be taken into account in considering these results. In the one case, when the revolution is at right angles to the line of flight, unless the surface offering resistance is directly opposite to the front of the projectile, so that this latter acts perpendicularly upon it; or, in other words, if the resisting surface present the slightest obliquity of inclination opposite to the projectile, whether this obliquity be obtained from the surface yielding and becoming inclined before [17] the pressure of the bullet, or whether it be owing to the fixed and natural form of the part impinged upon, the direction of its revolution will assist in causing the projectile to glance or roll off. The onward path of the bullet is altered in direction; the movement of rotation remains unchanged. These effects will be more marked if the surface against which the projectile impinges happen to be hard, such as the surface of some of the metal or leathern accoutrements covering the body, so that greater opposition is offered in the direction of the progressive motion; or if it be brought into contact with some of the bones which are placed superficially beneath the integument, such as the rounded cranium, or the body of a rib. In these latter cases, whether the skin be or be not penetrated at the point of impact, the bullet will have a tendency to glance off or to turn round the bone, and penetration of the adjoining cavity will thus be avoided.

A tough fascia covering the muscles of an extremity has often been found to be sufficient to prevent penetration under the same circumstances. On the other hand, when the axis of revolution is coincident with the line of flight, the revolving motion of a projectile joins with the progressive motion, and both together assist in penetrating the surface opposed to it. It screws itself in, as it were, point forward, with immense pressure. Even though there may be a certain amount of angular obliquity at the point of impact, so long as the spinning elongated bullet strikes the body or the surface of a limb in such a way that resistance is offered to the progress of the apex of the bullet, the revolution of the bullet on its long axis will assist the apex in effecting an entrance. The more rapid the revolution of the projectile, the more its penetration will be facilitated.[18]

The rate of the movement of rotation exerts another influence on a wound which a rifle bullet may happen to inflict—it affects the size of the opening of entrance. If the rotatory movement be very rapid, the projectile, in proportion to this rapidity, will resist any change in direction of the long axis on which it is revolving, and the movement of translation will be strictly in a line corresponding with the line of direction of the long axis of the bullet, its apex travelling front forward. On entering an opposing substance, like the surface of the body, it consequently forces an opening which corresponds in dimensions with those of the transverse sectional area of the bullet. But if the movement of rotation becomes slower, as after the bullet has gone some long distance, the revolution round the long axis is not rigidly maintained—it 'wabbles,' and, as a consequence, whirls with an increasingly wider sweep. Hence the outline of the spinning motion being wider, the opening of entrance in the soft structures of the body. and the track of the bullet through them, supposing it has still force enough to perforate the parts, will be likely to be wider too.

Effect of rotation on course of projectiles after penetration.—The different effects of the two kinds of rotation are equally manifested *after penetration* of the superficial textures of the body. The rotation of the spherical bullet will equally tend to divert it from a straight course on meeting any surface presenting sufficient obliquity within the body. And this affords one source of explanation of the circuitous and irregular tracks that used to be witnessed occasionally when spherical bullets were in common use. Such a bullet might enter the wall of the abdomen apparently almost in a straight line, but the obliquity offered by one of the layers of muscles pushed before it might be sufficient to divert it into a circuitous course round the abdomen between the muscles, without opening the cavity; while the progressive motion of the projectile would still be sufficient to enable it to force an exit at a point opposite to that at which it first penetrated

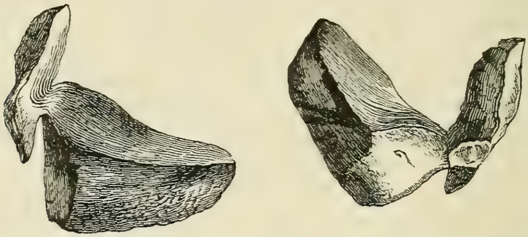
the abdominal wall.[19] The same thing might happen to a joint protected by a rounded capsule, such as the shoulder: the opening of first penetration being in front, that of exit opposite to it at the back of the shoulder, but the joint unopened, and the bone unbroken. In these instances, at a certain point behind the part first wounded, the relations of the bullet to the integuments, then practically before it, became nearly similar to its relations to the integuments at the point in front where it first effected its entrance; and as it still retained sufficient onward velocity and force for overcoming the resistance offered by them to its farther progress, it effected its passage through them without difficulty.

The spinning of the conoidal bullet on its long axis will, on the other hand, constantly help the projectile to go straight forward, by exerting exactly the same influence upon it after penetration that it did in assisting the penetration itself. The change from the one kind of rotation to the other has therefore not only tended to increase the number of severe wounds in warfare, but has further had the effect of adding to their depth and severity.

Effect of the rotatory motion of a projectile being continued after cessation of the movement of translation.—There is one other effect of the rotatory movement of rifled projectiles which may be briefly referred to. It is one which occurs when circumstances lead to the progressive motion being stopped without the motion of rotation being also arrested. Ordinarily, the same causes which put a stop to one put a stop to the other. But occasionally a bullet becomes so caught that it is unable to pursue a farther course forward, and yet sufficient movement of rotation remains to exert a turning action on the structure by which it has been caught. Such an influence may be observed when the apex of a rifle bullet comes into collision with the sharp edge of a thin bone, and when the bullet, in consequence, is partly bisected by the *vis a tergo* due to its velocity of translation. In such a case the divided surfaces of a leaden bullet are usually strongly marked by ridge and furrow lines, caused by the irregularly jagged edge of the broken bone by which the division has been effected; and the curvilinear direction of these lines often serves to illustrate the twisting force—resulting from the rotation of the projectile on its long axis—which has been at the same time exerted. The annexed drawing (fig. 38) is taken from a bullet connected with a gunshot fracture of the skull in the Museum of the Army Medical Department. It exhibits nearly one complete turn on its long axis after it had been caught on the margin of the broken bone. It is a Russian conical rifle bullet, and has been nearly separated into two parts by an oblique division from the apex to the base; the divided portions being only held together by a narrow isthmus of lead at one of the angles of the base of the section. This isthmus is

twisted round on itself like a piece of cord, carrying with it a thinner section of the projectile, or that section which was most easily acted upon by the twisting force. The ridge and furrow lines on the separated surfaces of the bullet are contorted from

FIG. 38.



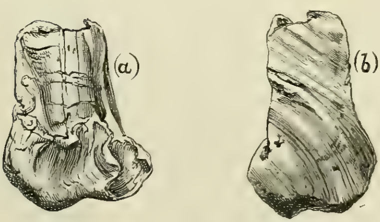
Drawing of a Bullet partially cleft by the edge of a Fractured Bone, and showing some of the twisting effects of its movement of rotation.

the right to the left, indicating the direction towards which the rotatory force has modified the direction of the bisecting force, and thus demonstrating the influence of the spinning quality under notice.

The effects of the rotation of a rifle bullet while undergoing compression, and during its subsequent bisection, are well shown in the specimen from which fig. 39 has been drawn. The portion of the bullet represented had lodged between the scalp and the cranium of a trooper of the 20th Hussars, who was wounded at the battle of Ginnis, in Egypt, in 1885.

When the movement of rotation is first impressed upon a rifle projectile, it accords with the degree of spirality of the grooves in the bore of the fire-arm. The twist of the rifling has varied considerably in different English rifles. The spiral in the Snider Enfield rifle made one turn in 78 inches; in the Martini-Henry rifle it has one turn in 22 inches; while in the new ·303-inch magazine rifle bullet the spiral makes one complete turn in 10 inches, or in nearly 33 times the measure of the calibre of the rifle. There seems, however, to be some reason for believing that the muzzle spirality of rotation of the bullet does not remain

FIG. 39.



Part of a Bullet, the Apex of which had been compressed, and the Bullet then cleft into two parts against the edge of a Fractured Cranial Bone. (a) Outer Surface and Crushed Apex; (b) Cleft Surface.

constant throughout its course; that the degree of twist, or the distance within which a complete spin takes place, constantly lessens from the time the projectile quits the muzzle of the rifle, owing to the greater opposition to the forward motion than to the revolving motion in its passage through the air. The resistance of the air to the forward motion causes the bullet to travel over a less space in each successive period of time, while the velocity of the rotation being very little opposed or lessened, the spirality becomes proportionably shortened in distance. When the forward movement is stopped, or nearly stopped, by a substance capable of opposing sufficient resistance, the shortened spiral may in some instances be rendered obvious to sight, as shown in fig. 38. It has been a question, whether this revolving motion has not exerted an influence in increasing the wounding effects on soft parts during the passage through them of former rifle projectiles, especially when the surfaces of the bullets have become roughened, or when, from the effects of more or less opposition to their forward progress, they have pursued their course with some irregularity, and not in a perfectly straight line. It may be readily understood that the width of the track of a projectile might become increased under such circumstances, and that even shreds of tissues might be caught and torn away by them in the act of revolution. This can hardly occur with the present armoured projectiles, the surfaces of which are not only hard but very highly polished and smooth. But the revolving movement might be one item in explaining the wide gaps that have been occasionally met with in wounds made by rifle projectiles, though no doubt the chief explanation consists in the fact that at high velocities a large amount of the energy of such bullets is communicated to all the substances, fluids included, with which they are brought into collision, and that these in turn act as so many secondary projectiles on the other substances in their vicinity.

Persistent rotation of spherical bullets.—The influence of a continued revolving motion of spherical bullets after their forward motion had been arrested was formerly recognised in the enlarged spaces at the bottom of flesh wounds in which such projectiles had happened to lodge.[20] The end of the wound was found to be larger than it was in the parts nearer to the surface, and this fact was attributed partly to the pressure and persistent rotatory action of the projectile after its power to pursue a forward course had been lost. There seems to be no reason for doubting the accuracy of this observation; the movement of rotation might equally well continue in the case of a small round bullet after its movement of translation had been stopped, as in a heavy spherical gunshot, such as in the instance which was noticed when remarking upon the qualities of 'spent shot.'

Effects of the qualities of projectiles when combined.—

An acquaintance with the separate effects of the various qualities which have now been described will enable an estimate to be formed of the destructive power of particular projectiles according to the relative amounts in which these several qualities happen to be combined in them. By analysis of this kind an explanation may often be found for the different degrees of gravity presented by wounds inflicted under apparently like circumstances, and occasionally also for the varying results of treatment in wounds of the same particular class. It has been shown that the principal changes which have been successively made in the material qualities of bullets—in their form, dimensions, and substance—have each separately had the effect of extending their range of fire and increasing their power of penetrating the human body; and still more so the changes in the impressed qualities, in the increased velocities of the movements of translation and rotation, which modern contrivances have succeeded in conferring on them. The result of these accessions of power in combination is witnessed in the enormous amount of destructive energy which these missiles now possess at ordinary ranges, and the relatively very great distances up to which their wounding power is retained. These effects have been practically demonstrated on a vast scale in the conflicts of Continental armies. They were sufficiently shown in our own service on the first occasion that British troops were armed in any large proportion with rifled fire-arms—when the Minié rifle projectiles were used in opposition to the spherical musket bullets of the Russians at the battle of the Alma; and they have been equally manifested since in the various contests in which British troops have been engaged with half-civilised peoples. The grave amount of surgical injury which may be inflicted by rifle projectiles in individual wounds is a subject which can be best considered when the wounds themselves are described. But I may here mention a fact which occurred in the last war in New Zealand, for it appears to afford a striking illustration of the different degree of surgical damage done by the spherical and cylindro-conoidal bullets under corresponding circumstances, in consequence of the differences in their qualities described in the preceding remarks. I refer to the opposite terminations of the cases of fracture of the thigh-bone among the Maoris wounded by the Enfield rifle bullets of the British troops, and of the same fractures among the European soldiers who had been wounded by the musket balls of the Maoris. Nearly every case among the British troops treated conservatively terminated successfully; while every case, without exception, among the Maori soldiers treated in the British hospitals ended in failure. Not one Maori preserved life or limb after a gunshot fracture of the femur. The distances at which the opponents were placed from each other when the wounds were inflicted were similar,

they were treated by the same surgeons, and had the same hospital and climatic advantages. It was, in fact, the nature of the wounds which was so different. My friend, the present Director-General Sir William Mackinnon, who served throughout the war, informed me at the time that the thigh fractures of the British soldiers in their early stages bore no resemblance to the thigh fractures of the Maoris, excepting that the fractures in both were compound; in the former series of cases they were generally single fractures, while in the latter series they were always extensively comminuted fractures with proportionate increase of damage to the soft tissues in the immediate neighbourhood of the shattered bones. Remembering the great strength and hardness of the human femur, and the force necessary to smash it up into fragments, the marked difference in the nature of the local injury and in the processes of repair demonstrate very clearly the difference in the destructive powers of the two kinds of projectiles by which the wounds were inflicted. The moral depression from which the Maori wounded doubtless suffered, in consequence of their reverses and disabled condition, was a superadded cause of hopelessness, so far as concerned their chances of recovery; but the main cause was that they were shot by Enfield rifle bullets, and not by musket bullets, like the English wounded.

It happily still remains to be proved what the effects of the several qualities combined in the recent ·303-inch magazine rifle bullet will be when the projectile is used in actual war. In the bullets of the magazine rifle, weight and diameter have been reduced practically to almost a minimum; but their velocity, both of translation and rotation, have been raised to an amount beyond all previous experience. Some military men consider that the reduction in weight and size of these projectiles have been carried beyond the limits which are essential for efficiency in an army weapon for inflicting wounds. So far, however, as experimental observation may afford the means of forming a judgment, the destructive energy of these narrow bullets will be in excess of the energy possessed by any rifle projectiles that have preceded them up to 500 or 600 yards, while their penetrative energy beyond that range up to 2000 or 2500 yards will still be such that no bodily structures will be able to resist their passage. At still longer ranges, whenever their velocity has become so far diminished as to be on a par with the velocity of the Martini-Henry bullet at any given point of its course, then the superior weight of the Martini-Henry projectile would give it an advantage, as a military weapon, in respect to destructive energy over the magazine narrow rifle bullet. It would have more power to resist the opposition of the air, owing to its superior weight, and from the same cause would strike a heavier blow on anything that opposed its onward

passage; on the other hand, the narrow ·303-inch bullet would meet with less opposition from the air in its flight. Thus, though by different means, in one bullet by being gifted with greater power to overcome resistance, in the other by less resistance being offered, the penetrative energy of the two projectiles would probably be maintained in nearly equal amounts over corresponding ranges, and the extreme range of the one would probably be found to be very nearly the same in distance as the extreme range of the other.

CHAPTER III

OTHER QUALITIES WHICH ARE, OR HAVE BEEN, SUPPOSED TO BE IMPRESSED ON PROJECTILES AND TO INFLUENCE THE NATURE AND CHARACTERS OF THE INJURIES INFLICTED BY THEM

Of these qualities, two only (*c*) the heat of bullets, and (*d*) a supposed poisonous quality attached to them, require notice.

(*c*.) **Heat of projectiles.**—One of the earliest notions concerning gunshot wounds was that they were complicated with a certain amount of *adustion*, or scorching, and this theory has been supported by some eminent surgeons of modern times. It was supposed in the old days that bullets acquired so much heat by the resistance they met with in their passage through the air, that they charred the surface of the wound which they inflicted in the flesh. The burning smart often felt at the moment of the stroke, the blackened aspect which is often presented by the edges of the opening directly after a wound has been inflicted by a bullet—which is in reality due partly to the direct effects of the contusion, partly to the ecchymosis of the structures immediately surrounding the opening, and not unfrequently also to the fact of the lips of the wound wiping off and retaining some of the gunpowder or of its smoke which had been deposited upon the projectile at the time of its being discharged from the fire-arm, together with the usual absence of hæmorrhage from such wounds, no doubt exerted an influence in originating the idea. Then some of the symptoms consequent on the injury which were common both to severe burns and gunshot wounds at the time—the separation of slough succeeded by granulating sores, the pain, surrounding inflammatory redness—tended to encourage the assumption. Probably also a predisposition to the belief existed in consequence of the still older conviction—one as old at least as the time of Aristotle—that lead was caused to melt by being impelled with great rapidity through the air. Aristotle quotes as an acknowledged fact the lead of flying darts becoming so heated as

to melt; and both Ovid and Virgil write of leaden bullets becoming melted owing to the rapid flight to which they were impelled by the powerful force of a slinger's arm.[21]

The doctrine of the heat of bullets producing some of the characters of gunshot wounds was first refuted in England by Thomas Gale, in his 'Treatise of Wounds made with Gonneshot, &c.,' published in July 1563. The first chapter of this treatise bears as the title of its contents, 'Gonnepowder is not venemous, *nother the shotte of such hotenesse as is able to warme the fleshe, much less to make an ascar.*' The arguments he adduces are the same as had been previously put forth in France by Ambrose Paré, and appear to have been copied from him.[22] Since Gale's work, no English writer on gunshot wounds has put forth the view that heat has any part in producing their characteristic features; but the idea has been revived of late years, though on different grounds, by Professor Tyndall in England, but developed more fully by certain Continental surgeons since the Franco-German war of 1870–71. The very experiments which Paré and Gale made to refute the theory of 'adustion' have been repeated in Germany. Dr. Ernst Küster, in a paper read by him in 1874 at the Berlin Medical Society, mentioned that small bags of gunpowder had been suspended in front of iron targets by Dr. Schädel in Heidelberg, and fired at by rifles. The same result ensued as in Paré's day; for though the powder bags were repeatedly cut open by the bullets, in no one instance was an explosion caused.[23]

Recent views on the subject.—The attention of modern surgeons seems to have been mainly drawn to the subject by the development of the law that impeded or arrested motion is converted into heat. Professor Tyndall, in a lecture delivered by him at the Royal Institution in June 1862, made the following remarks: 'Experiments and reasoning lead us to the remarkable law that the amount of heat generated, like the mechanical effect, is in proportion to the product of the mass into the square of the velocity. Double your mass, other things being equal, and you double your amount of heat. We, moreover, know the amount of heat which a given amount of mechanical force can develop. Our lead ball, for example, in falling to the earth, generated a quantity of heat sufficient to raise the temperature of its own mass $\frac{3}{5}$ths of a Fahrenheit degree. It reached the earth with a velocity of 32 feet per second, and forty times the velocity would be a small one for a rifle bullet. Multiplying $\frac{3}{5}$ths by the square of 40, we find that the amount of heat developed by collision with the target would, if wholly concentrated in the lead, raise its temperature 960 degrees. This would be more than sufficient to fuse the lead. In reality, however, the heat developed is divided between the lead and the body which it strikes; nevertheless it would be worth while to pay attention to this point to ascertain

whether rifle bullets do not under some circumstances show signs of fusion.'

This question was believed by E. Hagenbach to be settled by the results of experiments which he made at Basle. Dr. Hagenbach asserts that one of his experiments proved that when a conical lead bullet is fired from a distance of 100 metres, with a velocity of 320 metres, at an iron target, it is melted to a considerable extent. Around the point where the bullet had struck, the target was spattered with lead in the form of a white star; the bullet, which originally weighed 40 grammes, only weighed 13 grammes on being picked up, owing to loss of substance by fusion; while drops of melted lead, still warm, were collected in the vicinity of the target. According to Dr. Hagenbach's calculations, the mechanical equivalent in heat of the force expended in arresting the flight of the projectile was just what was necessary to heat the whole bullet and to fuse the portion of it which was melted.[24] These calculations were subsequently shown to be below the mark by Mr. J. Bodynski. Mr. Bodynski asserts that only the least part of the warmth developed was expended in melting the lead: the greater part disappeared in other ways, as through rebound, radiation, conduction, effect on iron plate, &c. (The calculations are given in the Appendix.) In a later paper Dr. Hagenbach has adduced some evidence to prove that parts of leaden shot are actually brought into a molten state in wounds when bones have been struck by them. He says that Professor Aug. Socin, who directed a military hospital in Carlsruhe during the war of 1870–71, had shown him several shot extracted from wounds, in parts of which were to be seen the effects of melting, and in parts iridescent colours, leading to the inevitable conclusion that there had been a development of heat from the motion of the shot having been arrested by striking against bone. In some bullets which had only traversed and lodged in soft tissues, the same effects were observed by Dr. Socin, though in less degrees. Professor W. Busch, of Bonn, also expressed his belief that rifle bullets on striking bones actually become melted and divided into slug-like parts, increasing their destructive effects in wounds.

Leaden bullets assume such a great variety of forms under collision with bones, that the strongest proofs are necessary before a conclusion can be arrived at that any of the appearances presented by them after collision are the result of melting. I have observed a large number of bullets of the old kinds that have been arrested in their flight by collision with bone, but none that I ever examined gave me the impression that their changed condition was due to the effects of melting. The iridescent colours observed on certain bullets may have been produced by the action upon them of the gases resulting from the explosion of the gunpowder, or may have existed before the bullets were fired, for such colours may be well

imagined to have been produced by a thin film of sulphuret of lead from the previous action of the sulphur in the gunpowder upon them. With reference to this subject, in March 1872 I wrapped up a small parcel of sulphur and enclosed it in several folds of white paper. At the same time an Enfield leaden bullet was scraped clean, so as to expose a bright metallic surface. The packet containing the sulphur and the leaden bullet were then placed together in a glass-stoppered bottle; the temperature at the time being about 60° Fahr. On the third day the bullet had lost its clean metallic surface, and exhibited iridescent colours similar to those which appear on the surface of molten lead.

To what extent wounds are affected by the heat of bullets.—The practical question, however, as regards surgeons resolves itself into this—When a rifle bullet at a high rate of speed is arrested in its flight by some part of the human body, are any effects of heat manifested in the wound? The correct reply is, I believe, that there are not. I have never from observation of gunshot wounds met with any condition that could justly be attributed to the effects of heat. It is, moreover, a matter of common experience to find in bullets which have been distorted by collision with bone, fibres of cotton or linen clothing, and particles of animal tissues, which have been forced tightly into them, without any scorching effect being manifest in them on closest observation. This could hardly be if any great degree of heat had been developed at the moment of impact. It is easy to understand that were the motion of a rifle bullet travelling with great velocity to be abruptly and completely arrested by collision with a perfectly rigid iron target, the lead might be partially melted as described, from a portion of the heat developed acting upon the apex, which had received the first and greatest force of the impact.

When a massive steel projectile is driven with immense velocity against a plate of iron several inches thick and passes through it, a very large amount of heat is generated by the prodigious force with which the two metals are brought into collision, by the resistance offered to the displacement of the iron, and by the mutual friction between the iron and the shot; so large, indeed, that Mr. Whitworth was able to turn it by conduction to a finely practical application. He used the heat thus developed to effect the explosion of bursting charges within hollow projectiles; regulating by the thickness of their walls the time for the heat to travel through them, so that the explosion should take place on the other side of the iron plates which the projectiles were directed against, just when they had passed through them. But experiments have sufficiently shown that when small projectiles are arrested by soft, moist, and comparatively yielding substances, no heat approaching the melting point of lead, or possessing charring power, is generated. The soft structures of the human frame cannot arrest the

course of a bullet when it is armed with a high rate of velocity. They only arrest its progress when the energy of the bullet has been very considerably expended, and then the softer textures give way one after the other before it, lessening by degrees, and at last, by their elasticity, putting a final stop to its further progress. If the projectile be opposed by bone, its force may be wholly spent in breaking it up into fragments, to many of which fragments a considerable part of its motion is communicated, and among which it may remain more or less broken or distorted. Part of the force will also probably be expended in fragmentation or deformation of the bullet itself. Thus no perceptible amount of heat is generated, for the arrest of motion has been comparatively gradual, and much of it has been imparted to other substances. If the momentum of the bullet be very high, the stoppage by the opposition of the bone will be only partial; part of the momentum will be expended in smashing up the bone, but the projectile, still retaining sufficient force for the purpose, will travel onwards and escape. The moist condition of the organised structures of the human body, too, favours the dispersion of the relatively small amount of heat which may be eliminated under the circumstances described. The conditions are so widely different that observation of the amount of heat developed by the sudden total arrest of progressive motion in a rifle bullet which is carried at a very high rate of speed against a fixed iron target, cannot warrant the inference that corresponding effects will take place in a bullet armed with similar velocity when brought into collision with a part of the human body. Practical experience indeed contradicts the notion of the surfaces of a wound being scorched by heat, whether a projectile has completely traversed the tissues concerned, or its passage has been arrested in the flesh, or by the opposition of a bone.

Effect of the heat generated by collision with bones on the bullets themselves.—Although, however, the lead is not brought to a molten condition, nor to such a hot state as to burn or scorch the organic tissues wounded by it, there seems to be ground for believing that when the progress of a leaden bullet travelling with great velocity is suddenly arrested by collision with bone, some amount of heat is generated in it, and, not improbably, sufficient to modify some of its physical characters. The lead will be rendered softer than it is at ordinary temperatures of the air, and in consequence be more easily altered in form, or broken. Portions of it will be more readily cut away by the rough edges, or sharp spiculæ, of the broken bone, and become fixed in their substance, or scattered in adjoining structures. Professor Busch, of Bonn, before a meeting of German naturalists at Wiesbaden in 1873, described some experiments to prove that lead loses its cohesion in proportion as it is heated, and Dr. Küster stated he

had obtained evidence of this fact by letting two bullets—the one cold, the other hot—drop from a height of about 6 feet upon stone. I repeated this experiment from a height of 11 feet, both with leaden and hardened bullets, but without obtaining any very marked results from it. The rate of velocity acquired by the bullets in this slight fall was probably too low, and if the drop had been extended, the higher of the two temperatures could not have been maintained. While the part pressed back by the blow from the fall against the stone floor on a leaden bullet at 57° Fahr. was flattened into a circular spot ·30 inch in diameter, on another heated to 320° Fahr. the flattened spot was only increased to ·33 inch. A corresponding depression on a Martini-Henry bullet at 57° Fahr. was ·17 inch in diameter; in another heated to 320° Fahr. the flat marked impressed on it was ·19 inch in diameter.

But on subjecting the bullets to high determinate pressures under similar differences of temperature, I found the results sufficiently obvious. A hardened Martini-Henry bullet subjected to a pressure of 378 lbs. midway between its apex and base, at a temperature of 57° Fahr., hardly bore any mark of the pressure. The cylindrical portion of the bullet was flattened at a very small spot from its normal transverse diameter of ·45 inch to ·40 inch, while another Martini-Henry bullet raised to a temperature of 320° Fahr., when subjected to similar pressure, had its cylindrical portion so widely spread out that its substance was reduced to ·15 inch in thickness. A leaden musket bullet ·75 inch in diameter, when heated to 320° Fahr. and subjected to a pressure of 378 lbs., was flattened out to an extent of two inches, and was reduced to ·15 inch in thickness. The bullets employed in these experiments are preserved at Netley.[25] This loss of cohesive force from the progressive motion of a bullet being suddenly arrested and converted into heat may probably in part account for the extensive breaking up of its substance which has been so frequently met with in gunshot fractures; and, if this be true, the aggravation of injury to the surrounding parts in consequence of the dispersion of fragments of the metal of the projectile will after all be partly traceable to the effects of heat. The observation is of interest, because it shows that the notions of the ancients regarding the generation of heat, and the softening of the leaden projectiles of slingers, consisting probably of pure and very malleable lead, were not without some foundation; and it is also not a little curious that a belief which had once held sway, and then been discarded for centuries, should have been revived in our own day, and be so far supported by scientific investigation.

The fusing point of an alloy of equal parts of tin and lead would be nearly 100° Fahr. lower than that of pure lead, taken at 608° Fahr.; but with the two constituent metals in the propor-

tions in which they are employed for the Martini-Henry projectiles, the fusing point is probably not more than 15° Fahr. less than the fusing point of lead. But even with this diminution in the heat required for melting, it might be expected that the heat generated by arrest of motion would cause softening of the bullet more readily, and therefore more injurious effects, with a Martini-Henry projectile than with a leaden bullet. On the other hand, the hardness resulting from the combination of tin and lead must be taken into account; and it would require more careful and extended observations than have yet been made to determine the extent to which hardened bullets, whether the lead be alloyed with tin or antimony, are influenced by the heat developed by sudden arrest of their motion, as compared with what happens when bullets of pure lead are employed.

(*d.*) **Poisonous influence of projectiles.**—The belief which once existed that a musket projectile had a direct poisonous effect upon the structures mutilated by it, and, through them, on the constitution of a patient, is chiefly noticed here on account of the injurious influence it exerted for many years upon the treatment of gunshot wounds. The primary appearances of the injury, the same that originated the idea of the structures having been burned, the usual sloughing of the track, and surrounding inflammation, no doubt encouraged this erroneous conviction; but it would not have held its ground had it not been for the fatal results which frequently followed gunshot wounds in those days in cases where neither the extent nor apparent gravity of the injuries sufficed to account for the deaths of the patients. It is evident enough now that this mortality was due in part to the foulness of the discharges from the wounds and the unhealthy condition of the neighbouring structures, brought about by the irritating applications to which they were subjected; but more especially to the want of due attention to cleanliness, and the neglect of all hygienic rules. The ill consequences of such wounds usually resulted from septic poisoning, attributable to the unsanitary conditions under which the wounded men were treated, and not, as was supposed at the time, to any poisonous influence of the projectiles by which the injuries had been originally inflicted.

To Ambrose Paré is certainly due the most early published attempt to refute this error. The first of his treatises, which had this object in view, appeared in the year 1545. Paré has left a very honest account of the chance way in which he discovered that burning the wounds with scalding oil, which was the common mode of treatment with a view to get rid of the poison when he was first employed in field-surgery, was not only unnecessary, but even hurtful;[26] and how he then came to the conclusion that 'wounds made by gunshot are more refractory and difficult to cure than others, not because they partake of any

poisonous quality, but through the fault of some general cause, as the ill complexions of the patients, the infections of the air, and the corruption of meats and drinks.' Paré answered those who thought the poison was derived from the gunpowder by showing the harmlessness of its ingredients, separately and combined, when applied locally or taken internally; and he replied to others who thought that the poison sprang from some poisonous substance being mixed with the lead by showing that if this poisoning could be practised, the flame of the ignited powder in the gun would cause the poison to be dissipated before the bullet left the fire-arm.

Persistence of faith in the poisonous qualities of fired bullets.—But though Paré refuted the doctrine of gunshot wounds being poisoned wounds, not only by arguments, but by his successful treatment of them by simple remedies, the belief continued to prevail, not only among combatants, but also among surgeons, for a long time after Paré wrote. More than a century after Paré's first work on the subject was printed, we find, even in Paré's own country, a systematic work published on gunshot wounds, in which the author, Pierre Dailly,[27] states that the experience he had had in armies had made him conclude gunshot wounds to be truly poisoned wounds. Dailly advances a long series of arguments to overthrow the arguments of Paré and others who maintained that such wounds were not venomous. His directions for the treatment of these injuries were based on the assumption that the most important point was to get the poison out of them. It included scarifying the edges of the wound, applying cupping glasses, dilating the track by incision, so that the poison might flow away with the blood, applying dressings calculated to eliminate the poison from the wounded structures; while general bleeding, purging, and lowering remedies were to be employed, in order to clear the constitution of the patient of the virus circulating in it.

Even so late as the year 1848, on the occasion of the insurrections in Paris, the notion of poison being conveyed by the bullets, and causing the mortality of the wounds inflicted by them, prevailed to such an extent that several eminent surgeons thought well to speak on the subject at the Academy of Medicine. M. Roux, in reporting on the wounded who had been under his care in the Hôtel-Dieu, stated with regard to the wounds being poisoned: 'As to the nature of the projectiles, neither direct examination, nor any peculiar symptom observed in our patients, raised suspicions regarding it. I do not believe that they were poisoned.'[28]

M. Velpeau, on the same occasion at the Academy of Medicine, gave some explanations in exculpation of the prevailing belief of gunshot being poisoned wounds. 'There is still,' he said, 'a

question of the poisoning of gunshot wounds on every occasion of insurrectionary fighting by armed citizens. I can scarcely conceive it to be possible for bullets to deposit in the tissues which they traverse any substance capable of compromising the life of a wounded man; either I am very much deceived, or all that has recently been said on this point should be classed as fables created by fear or love of the marvellous. But the venomousness of gunshot wounds can be regarded in another manner: such wounds have no need to seek for poisons from without, for they contain the principles of poisoning in themselves. The layer of tissue ground up by the projectile decomposes, quickly becomes putrid, and stagnates in the midst of the living parts. One knows with what promptitude animal matters become decomposed under the influence of heat, moisture, and contact with animal tissues. Who can contest that, in decomposing, the elements of putrefaction will not often give rise to dangerous compounds, which in some way may happen to pass into the circulation? Is it not allowable to say, therefore, that gunshot wounds contain a veritable poison, and that the accidents they so frequently give rise to are sometimes due to this kind of cause?'[29] Had M. Velpeau known the alleged facts described farther on, which tend to prove that bullets, after passing through clothing, may carry microbes into wounds, without detriment to the vitality or productive power of these minute organisms, he might have advanced an additional argument to explain the presence of a poison in them and the consequent accidents to which he referred.

Mutual recriminations on the subject during the Franco-German war.—That the notion still existed at a later time on the Continent was shown by the mutual accusations of the use of poisoned bullets during the war between France and Germany in 1870. A correspondent to a German journal, dating his letter from Rheims on September 12, 1870, wrote: 'We can say with justice that the use of the mitrailleuse is contrary to the existing rules of warfare; it causes a wound with ragged and uneven edges, which is most difficult to heal; the difficulty arising in all probability from the fact that the bullets of the mitrailleuses contain a calcined poisonous substance in the lead.' Similar accusations appeared from time to time during the war.

Views regarding the poisonous qualities of bullets in Britain.—Paré's views, put forth by Gale, no doubt exerted a beneficial influence in shaking faith in this error in England; but it continued to prevail for many years after Gale wrote. Clowes, while not admitting gunshot wounds generally to be poisoned wounds, had no doubt they were so occasionally. He even performed experiments to test whether the flame of ignited gunpowder during the discharge of the shot would destroy any poisonous material which might previously have been impressed

on the bullet, and he considered that they proved the flame 'could not burn out the impression of a poisoned bullet.'[30] It is difficult to say when the idea of gunshot projectiles being imbued with poisonous properties finally died out in this country, but it certainly does not appear to have held its ground so long as it did on the Continent. Wiseman, in his works, repudiates the notion, and attributes the origin of the belief to the fatal results of the local inflammation and gangrene induced by the improper applications used in dressing gunshot wounds; and we find scarcely any reference to it in the works of subsequent English writers. Had some of the chemical explosive compounds in use at the present time been employed in the warfare of former days instead of gunpowder, there might have been some apparent ground for the conviction that the wounds caused by them were complicated with 'adustion and venom;' but without these modern refinements in explosives, nothing but the darkness which obscured all branches of scientific knowledge could have permitted the notion to have taken the firm root it did in the minds of so many of the surgeons who were engaged in treating gunshot injuries. That the error should have widely prevailed among combatants, and that it should have maintained its hold, supported by prejudice, hate, imperfect information, and credulity, notwithstanding the progress of learning, is no more to be wondered at than the existence of numerous other errors equally destitute of any foundation of truth.

Conveyance of septic germs by bullets.—Although no surgeons of recent years have held the belief that gunshot wounds can ever have been poisoned by the deliberate application of poisonous materials, whether vegetable or mineral, to the projectiles by which they have been inflicted, doubts have been raised as to whether septic germs might not be occasionally carried into them in a state capable of growth and development, and, in this way, what might be regarded as a poisonous influence, be exerted upon them. Several surgeons have performed experiments with the object in view of bringing these doubts to a settlement. Probably the most complete investigations into the subject have been those which have been made in America. The series of experiments referred to were carried out at the pathological laboratory of the John Hopkins University and at the Frankford Arsenal in the United States, and had for their special purpose to determine whether bullets which had been previously contaminated by septic germs could infect wounds inflicted by them, or whether these bullets, after contamination, would be rendered aseptic by the heat to which they were exposed at the time of being discharged from the fire-arms. The particular details of these trials may be seen in the Report of the Surgeon-General of the U.S. Army to the Secretary of War for the year 1893. The following

are the chief conclusions which these trials led to on the subject: (*a*) The majority of gunshot wounds are aseptic, because the vast majority of the projectiles inflicting them are free from septic germs. (*b*) Anthrax spores, or bacilli, when applied to the projectile of a portable hand weapon (pistol bullet), are seldom, if ever, entirely destroyed by the act of firing. (*c*) When a gunshot wound is inflicted upon a susceptible animal by a projectile infected with anthrax bacilli, the animal becomes infected with anthrax, and dies in a vast majority of instances from this infection. (*d*) The streptococcus of erysipelas and the bacillus pyogenes soli of Bolton, placed upon the bullet of a ·45-inch calibre Colt's revolver, are not always destroyed by the act of firing, and are liable to cause infection. (*e*) Projectiles from portable hand weapons are not sterilised by the act of firing. (*f*) A septic bullet can infect a gunshot wound. (*g*) The act of firing does not impart enough heat to the projectile to destroy organisms placed upon its surface. That these deductions were warranted by the results of the experiments as they were conducted cannot be doubted; but there seems to be some ground for questioning whether similar infective effects would have been observable had the projectiles travelled the distances at which soldiers are generally wounded in battle, more especially if, before inflicting wounds, they had, as usually happens, passed through clothes or any of the accoutrements worn by the wounded men.

CHAPTER IV

(B.) ON THE CONDITIONS APPERTAINING TO THE PART OR PARTS OF THE BODY INJURED BY WHICH GUNSHOT INJURIES ARE MODIFIED IN THEIR PRIMARY CHARACTERS AND DEGREES OF GRAVITY

THESE conditions are comprised in (*a*) the angle of impact, or relative position of the part struck to the projectile striking it; and (*b*) the anatomical situation of injury; together with the course the projectile takes after penetrating the body, and the depth to which it penetrates.

(*a.*) **Angle of impact.**—Some of the consequences of the smaller forms of projectiles striking the surface of the body in a direct or nearly direct line, or coming into collision with it at certain angles of obliquity, have been already referred to when the different kinds of rotation impressed on musket and rifle projectiles were explained. The effects then alluded to had relation to the occurrence of penetration, or escape from it, on bullets striking the bodies of persons opposed to them. But beyond these issues,

which, of course, are of first importance, differences in the forms, sizes, depth, and other features of wounds when inflicted, greatly depend on the line of direction of the projectile at the moment of impact. There also remain to be mentioned some effects which occasionally result when massive projectiles impinge against portions of the surface of the body at a very acute angle of incidence, or pass in nearly a parallel direction across them, and these will be described in the chapter on the special features of injuries produced by such projectiles.

(*b*.) **The anatomical situation and course of injury.**—The special characters of wounds, and their varying degrees of gravity, which depend on the situation of the part of the body injured, and (*c*) on the course taken by a projectile after penetration, will be elsewhere considered. They are manifestly subjects which can only be properly discussed when wounds of particular regions of the body are treated upon.

SECTION III

ON THE CHARACTERISTIC FEATURES AND DISTINGUISHING SIGNS OF GUNSHOT INJURIES

Introductory remarks.—Having considered the leading qualities of the projectiles by which gunshot injuries are produced, and their nature and gravity influenced, the principal features of the injuries themselves may now be described. These can be most conveniently studied under (1) the external appearances, or those presented to view according to the kind and quality of projectile by which the injury is inflicted; and (2) the internal conditions, also according to the kind and quality of projectiles causing them. The former of the two divisions may for convenience be again subdivided into injuries produced by solid and those by gaseous projectiles. The injuries produced by small shot in general use for sporting purposes also present some special features, and they will be separately described.

CHAPTER I

CHARACTERISTIC FEATURES OF INJURIES BY SOLID PROJECTILES

The injuries produced by solid projectiles are of two kinds—contusions and wounds. The features of gunshot contusions will be first described, and then those of open wounds.

The contusions that used to occur from solid spherical gunshot in warfare are no longer met with, and contusions from the existing kinds of elongated hollow projectiles before explosion can only happen very exceptionally. It is from the scattered fragments after their explosion that contusions are now chiefly met with in military practice—the degree of contusion varying from a slight ecchymosis to entire disorganisation, according to the weight, velocity, shape, and incidence of the missile by which it is caused. Contusions from rifle projectiles are only likely to take place in future when not only their force is in great measure expended, but also when some sufficiently resisting substance has intervened between the bullet and the part of the body struck by it.

Contusions from Solid Projectiles.

Gunshot contusions.—Slight and relatively unimportant contusions of the body produced by projectiles, whether by a fragment of a hollow shell, an indirect projectile, or a bullet, after their force has been in a great measure expended from the distance they have travelled, or through any other cause, from their slanting incidence, or from the opposition to their progress from some substance covering the part receiving the blow, do not differ in appearances any more than they do in their nature from contusions produced by ordinary means. The usual signs of contusion —ecchymosis, local pain, and tenderness on pressure—are presented in both cases alike, and they equally vary in degree and extent according to the force and shape of the instrument by which they have been produced; and also, in some measure, according to the nature of the surface struck, whether some thick layers of muscular tissues lie beneath it, and these tissues be relaxed or in a state of tension, or whether it overlies yielding organs, such as the movable viscera of the abdomen, or covers some of the superficially placed bones of the body.

But the contusions caused by projectiles which are brought to the notice of military surgeons are usually more severe in character. Instead of mere superficial ecchymosis, the injury is one which has been followed by considerable effusion of blood, and occasionally, notwithstanding the integuments have remained intact, especially when the missile causing the contusion has been of large size and heavy, the collection of blood thus effused is in very large quantity, and gives rise to much trouble in its treatment under the conditions of field practice. The swelling, its sudden appearance after the stroke of the projectile, the absence of pulsation, tactile fluctuation, and other ordinary signs sufficiently indicate the nature of the lesion which has occurred. The fluid thus effused may be gradually absorbed, but occasionally collects in a particular part, and forms a depôt, which will now and then remain chronically in a liquid condition, and at other times will form a hard and solid tumour of coagulum. Such collections may persist for a long time, and if not ultimately absorbed, may give rise to troublesome symptoms and grave developments which will lead to the necessity of surgical interference.

With projectiles of increased weight and armed with a greater amount of force, the contusions inflicted by them may assume still more serious characters. The vitality of the skin, although remaining entire, may be very gravely compromised; while in the most intense degrees of contusion, structures lying deeply beneath the surface may be more or less destroyed, nerves and vessels torn asunder, and muscular tissues reduced to a kind of pulp.

Under such circumstances the gravest consecutive results may always be anticipated. Inflammatory action is excited, diffused suppuration occurs, the skin ulcerates or mortifies, and the injured structures beneath are exposed to all the dangers of septic infection. In instances of the most intense contusion, in which almost complete attrition of the deeper tissues is accompanied by loss of sensibility and destruction of functional power, the usual signs of mortification present themselves very rapidly. The extent of the lesion which has been inflicted then becomes a matter of serious import, not only as regards the prognosis of the case, but also in relation to matters of treatment.

Some varieties of these contusions by large projectiles, in which the principal lesions effected are out of sight and deeply placed, are attended with peculiar conditions, and have given rise to such singular views regarding the manner of their production, that a special account of them appears desirable. Such especially are those forms of contusion which have been ascribed to the '*wind of a ball.*'

Subcutaneous contusions without external marks.—Among the wide variety of injuries from gunshot, surgeons have frequently met with cases in which internal mischief of the gravest nature has been inflicted, without any external marks of violence to indicate the fact of its having resulted from the stroke of a projectile. These accidents have usually resulted from the grape or round shot in former use, but occasionally follow the stroke of a large fragment of shell having a smooth and convex surface. A viscus of the abdomen, the liver, stomach, bladder, or part of the intestines has been lacerated, yet no bruising of the parietes has been observed; a strong tendon like the tendo-Achillis has been ruptured, without any mark having been left by the shot on the skin; symptoms of cerebral concussion have shown themselves, or rupture of a sinus and fatal effusion of blood has occurred, yet no lesion of the scalp has been detected.[1] The records of most campaigns afford examples of such wounds. Even bones have sometimes been comminuted without any wound of the integuments or change in the appearance of the skin to indicate the injury. Two cases of fracture of the forearm by heavy projectiles, without any apparent external lesion, are recorded among the injuries in the French army during the Crimean war; in one of these the internal structures were reduced to a mass of pulp. A similar injury of the forearm occurred in the British army. In another instance the bones of a cranium were shattered into fragments by a cannon shot, while the scalp remained entire and without indications of injury.

The following cases, which were communicated to me by my friend the late Inspector-General F. Innes, appear to be such instructive examples of the kind of injury I am describing, that I am induced to quote them as further illustrations.

During the Indian Mutiny, when Havelock's field force was advancing on the Alumbagh, a gunner of Maude's battery, during a halt, lay along his gun to rest himself, the ground being very wet at the time. While lying in this posture, a round shot from the Sepoy works glanced along his right thigh, though this occurrence was not recognised at the time, then passed obliquely across his abdomen and chest, and finally smashed the upper part of his left arm. The man's trouser was not torn, but the projecting portions of some folds of his knitted vest were cut away by the passing ball, and corresponding holes left in the garment. Neither the skin of the thigh nor that of the trunk exhibited any signs of injury. The arm was amputated at once. On the third day after the operation, Dr. Innes, who was in charge of the field hospital at the Alumbagh, had his attention called to the patient's thigh. There he found a large slough on the inner aspect nearly as broad as his hand. This slough extended deeply enough to expose the femoral artery in the superficial part of its course. No slough nor discoloration took place on the trunk, nor was there any visceral disturbance; so that it was obvious the shot in rolling onward had pressed, however lightly, upon the thigh, but had not exerted any downward pressure on the abdomen or chest during its passage, although it had torn away pieces from the folds of the man's jersey. The thigh had been contused by the shot, though not visibly so; the trunk had altogether escaped. The man had not consciously felt the passage of the heavy shot across his thigh and body, or, if felt, it was so overwhelmed in the pain of the crushed arm that no recollection of it remained.

In the same campaign Brigadier-General Sir D. R., while with Lord Clyde's force advancing to the relief of Lucknow, met with the following accident. A round shot glanced across the back of his neck, and cut away the back of the collar of his uniform coat, the shirt underneath, and part of a hair chain. The skin was unbroken, and showed no trace of a bruise, yet there was no ground for doubt, from the first, about the neck having been subjected to the pressure of the projectile, for a certain amount of general paralysis immediately followed the passage of the shot, plainly indicating some concussion of the spine. Subsequently the skin sloughed away as well as the subcutaneous cellular tissue, and a deep sore, necessitating long treatment, resulted. The injury the parts had been subjected to, as well as its severe nature, were thus sufficiently proved.

Similar injuries from shell fragments.—As already mentioned, it is not only by heavy projectiles remaining entire that injuries of the kind described are produced; they also result from projectiles of irregular forms. An officer of the 42nd Highlanders, Captain F., met with his death in the Crimea from an injury to the abdomen. He was struck across the epigastrium by a large fragment of shell

weighing about 22 lbs., while he was under cover of a parapet in the trenches. He fell prostrate, and shortly afterwards died as he was being carried up to camp. There was not the slightest bruise or discoloration of the skin, no swelling, no indication of any mischief apparent to the eye, and some officers who saw him at the time of his death would hardly credit his having been hit by the projectile. But the evidence of those who had been near him in the trenches rendered it certain that he had been struck by the fragment, and his symptoms sufficiently showed that his death was the result of internal hæmorrhage, consequent on the injuries it had inflicted.

Further explanations of such injuries.—The difficulty of reconciling the several facts noticed in such instances, together with the vague descriptions by patients of the sensations they had experienced at the moment of being injured, the erroneous impressions made upon even enlightened observers [2] owing to the almost instantaneous manner in which such injuries are inflicted, and the absence of evidence, by sight or otherwise, of direct contact of the projectiles, led many eminent surgeons in former years to find an explanation of these crushes in the supposition that masses of metal projected with great velocity through the air might cause them indirectly by aërial percussion, or, as it was usually called, by the 'wind of the shot.' [3] It was believed either that the air was forcibly driven against the injured parts, as a consequence of powerful pressure from the missile during its flight, or, that a momentary vacuum was created as it flew past, and that the forcible rush of air to refill this blank was the origin of the hurt. Some, however, doubting the correctness of this theory, sought other modes of explanation. Dr. Spence, a surgeon of the Royal Navy, argued that such occurrences in naval warfare were due not to the shot, but to light substances, as pieces of rope-yarn, parts of bedding, &c., being carried along by it, and then being brought, with great velocity, into contact with the part of the body injured.[4] Electricity, supposed to be developed by the friction of the shot in passing along the bore of the gun, was also called into aid in explaining them.[5] All these hypotheses are now abandoned, I believe, by English military surgeons, though a strong belief in them still exists in the minds of many combatant officers,[6] and although even so late as the Franco-German war of 1870–71 observations during the siege of Strasburg led some surgeons still to express doubts on the subject. So many instances have occurred of gunshot passing close to various parts of the body, as near as conceivable without actual contact, without any such consequences happening as those which have been attributed to windage,[7] as to lead to the almost necessary conclusion that the theory must have been in all instances fallacious. Portions of uniform and accoutrements have not unfrequently

been torn away by shot without injury to the soldier himself. Cases are on record in which hair has been shaved off from the head, and the external ear,[8] and other prominent parts of the body have been carried away by gunshot, without deeper mischief ensuing. And lastly, proof against the supposed force exerted indirectly through pressure of air by a passing shot has been obtained by experimental trial.[9]

Modern views on the subject.—The true explanation of the phenomena observed in cases of so-called 'wind contusions' is to be found in the particular direction or degree of obliquity with which the missile has happened to impinge against the elastic skin, together with the relative situation of the internal organs injured to this missile and to other hard substances in their immediate neighbourhood. The surface itself is not directly torn or cut into, because the impact of the projectile has not been sufficiently direct to effect an opening; but the parts beneath are crushed by the pressure to which they have been subjected under the combined influence of the momentum of the heavy projectile on the one side, and some hard, resisting substance on the other. Thus, on a shot passing obliquely across the abdomen, the ready mobility and elasticity of the skin may enable this supple structure to yield by stretching to the tangential strain to which it is exposed, and to descend into the soft structures beneath, while at the same time viscera are ruptured by the projectile forcing them against the vertebral column. In a similar way the weight of a heavy missile passing slantingly along a forearm may possibly crush the bone between itself and some hard substance against which the arm may be accidentally resting, without producing lesion of the interposed skin. The crushing impulse fails to act on the yielding integument, but expends itself on the hard, resisting parts beneath. In cases where vision has been impaired, the missile has probably glanced along the forehead or upper part of the cheek, producing concussion of the optic nerve or other ocular lesion, while the yielding of the skin and whole head to the weight brushing across it has prevented the occurrence of any obvious injury.

It seems probable that in most, if not in all, of the instances in which in former days these injuries were produced by round shot, the peculiar result which ensued was not only due to the tangential direction of the shot, but also to the fact of its having *rolled over* the surface covering the injured structures; the movement of rotation being due to the same causes which led to the rotation of small spherical bullets, previously described, from the old smooth-bore muskets.

The first Baron Larrey, who examined many fatal cases which others were inclined to attribute to 'vent de boulet,' has related that he always found so much internal disorganisation as to leave

no doubt in his own mind of its being the result of pressure by the projectile. He gave the following explanation of the absence of superficial lesion. He argued that in such cases the surface of the body had been struck by a cannon ball in the latter part of its flight, when it had undergone a change of direction from nearly straight to curvilinear. Under such a condition, a ball would turn round a part of the body as a wheel passes over a limb, instead of forcing its way through it; and while the elastic structures would yield to the force, muscles and internal organs, offering more opposition, would be contused, or bones broken. While agreeing with the probability of the explanation afforded by the existence of a revolving motion in the spherical gunshot, and its share in the production of the peculiar injuries under consideration, there are strong reasons for the belief that this motion had existed in the shot throughout the whole line of its flight, from causes already explained, rather than that it only occurred towards the last part of its course.

It is not unlikely that, in some of these cases, especially in those in which visceral lesions are involved, the remarkable absence of superficial ecchymosis is partly attributable to the draining of the surface by the rapid effusion of blood within. Violent spasmodic muscular contraction may also join with the direct stroke in producing the effect in some lesions, such as those in which rupture of tendons has occurred without marks of external injury.

Remarkable qualities of the tegumentary covering of the human body.—While remarking upon these grave, often fatal, sub-tegumentary contusions, the peculiar distensibility, elasticity, and toughness of the skin may be advantageously called to mind. These qualities of the cuticular covering of the human body are exhibited in many ways; but in no way is the remarkable extent to which they exist so forcibly shown as it occasionally is in gunshot injuries. Every one is familiar with cases where bullets have entered the body with great force, traversing all the tissues, including bone, with ease, but which are yet found lying somewhere just beneath the skin, by the elasticity and resistance of which their further progress has been prevented. We see the same qualities manifested, sometimes in a remarkable degree, on the integuments of parts of the body which have been subjected to a sudden violent propelling force from an explosion of gunpowder. Even in those parts of the extremities where the bones are placed at comparatively little distance beneath the integument, as in the hand and forearm, leg and foot, the bones have been frequently found crushed and comminuted, strong tendons torn, and muscles pulpified, with scarcely any lesion of the skin on the side against which the explosive force has been directed. There may be local rents of the skin on the opposite side, but these will

usually be the result of some of the bone fragments having been propelled through it. These effects are sometimes witnessed in the accidents which occasionally occur at artillery practice from the premature explosion of gunpowder.

The following seems worthy of being recorded as a notable illustration of the power of resistance against gunshot injury possessed by the common integument of the body. On the day of the battle of the Alma, while the men of the 42nd Regiment were lying down in rear of the vineyards previous to the advance of the First Division, a round shot struck the ground about 20 yards in front of the first line of men, bounded, and in its fall struck Private C. in the abdomen and killed him instantaneously. After the action, on the body being raised for burial, it was found to be exceedingly heavy, and, on examination by Assistant-Surgeon, now Sir William Mackinnon, K.C.B., the round shot, about a 24-pounder, was found lying in the abdomen, imbedded in the viscera. The integuments in front had been torn asunder, but not extensively; in fact, the length of the wound seemed less than the diameter of the ball, part only of the surface being visible through the opening. The integuments of the back were not in the slightest degree broken, though they were stretched tensely under the mass of iron, the round surface of which was presented to the hand on touching the back, instead of the prominence of the spinal column. The spine had been ground to pieces and pushed aside with the mass of other disintegrated structures, but the elasticity of the skin had preserved its texture entire. When the body was lifted from the ground, the shot bulged out in a pouch of the skin of the back, by which, notwithstanding its weight, it was still retained.

It is not often that the opportunity occurs of witnessing the qualities of the skin just described as strikingly in the injuries that occur in civil life as they are in those met with in military practice. But in the following instance they were exhibited even more forcibly than they were in the case last narrated. In June 1870, a railway train, consisting of three carriages, a break van, and an engine weighing 32 tons, passed over a young man while he was lying across one of the rails of a line of railway. On examination of the body afterwards at University College Hospital, no wound was observed on the surface, but on opening the abdomen, all the abdominal muscles were found completely cut through horizontally and retracted, leaving a gap from 5 to 6 inches in width. The muscles of the back were in the same condition. The right kidney was cut in half. The transverse colon and a large portion of the ileum were cut away, detached, and lying free in the abdomen. The body of the third lumbar vertebra was crushed literally to powder. In short, everything was divided except the skin; the man was actually cut in half, but the con-

tinuity of the tegumentary covering prevented this fact from being rendered obvious until the post-mortem inspection exposed the severed parts to view.[10]

Other contusions from glancing gunshot.—In other instances where a heavy projectile has struck the surface obliquely and without breaking the skin, there is evidence enough of actual contact; the marks left after the passage of the projectile show the fact. The surface is discoloured by ecchymosis; there is pain; probably constitutional stupor; general swelling speedily follows; and there is great tenderness on movement of the injured parts. There may be no sufficient means of diagnosing accurately the real amount of mischief which has been done to the parts beneath the surface by the projectile. The marks of the contusion may be only relatively slight at first, and an unwary observer may be easily thrown off his guard by the small amount of external evidence of injury under the circumstances, and be led to state that after some few days the person struck will feel no inconvenience from what has occurred. But in almost all such cases the injury done will be found to be much more serious than it appears to be. Notwithstanding the oblique incidence of the projectile, the contusion will often extend to a considerable depth, and generally will be more severe as the depth increases than it is at or near the surface, especially if the soft parts lie over a broad flat bone like the ileum. This kind of injury has been often spoken of among soldiers as the 'brush of a shot,' in contradistinction to the injury already described, and attributed to the 'wind of a shot,' in which no external evidence whatever of the contact is presented either at the time of the injury or perhaps subsequently.

Indirect contusions from gunshot.—An interesting class of contusions is occasionally met with among gunshot injuries, in which the injured parts are not struck directly by a projectile, but suffer from the force being communicated to them either by transmission through intervening parts, as when violent momentary stretching, or intense vibratory agitation propagated through them, becomes concentrated on particular points, or else by violent commotion from the original impulse of the projectile acting independently on a part remote from the point of impact. In this way alone can be explained the occasional accidents that are met with of extensive ecchymosis occurring in parts at a greater or less distance away from the spot subjected to direct injury by a heavy shot.

Contusions propagated in the manner referred to from a centre of injury, whether this be a contusion or open wound, will not always manifest themselves immediately. Thus, if part of a limb be carried away by shot or shell, it will not unfrequently be observed several days afterwards that some of the parts above the

wound—parts which had not seemed to be at all involved in the injury at first—exhibit the ordinary signs of contusion. There has been laceration of the delicate cells of the areolar tissue and of the very minute capillary blood-vessels; but such injuries are only rendered visible to the eye by the colouring due to the escape of serum stained with the red particles of the blood, and this extravasation does not take place until the impulse of reaction gives rise to it. The condition of the parts is nearly the same as if they had been directly contused by the projectile, and they require the same treatment as if they had been. It is necessary to be prepared for the liability of adjoining parts to assume this condition when primary amputation has been performed for a gunshot wound. In a case that came under my cognisance, in which the leg of a soldier had been smashed by a heavy fragment of shell, the surgeon, with a proper desire to amputate as far from the trunk as practicable, performed the operation below the knee, through parts near to the wound which seemed quite unaffected by the stroke of the projectile. The skin was natural in colour, and the anatomical structures through which the knife passed were free from visible infiltration of effused blood, and presented a normal aspect. On the following day, after reaction had set in, the knee and greater part of the thigh exhibited the usual discoloration of ecchymosis, darkest near the line of incision, and gradually lessening in hue as it became more distant. The thigh and the stump became swollen and œdematous, and from the latter exuded an ill-looking discharge. These changes were at first attributed to the use of an unclean knife, but they were undoubtedly due to the violent commotion to which the structures of the upper part of the limb had been subjected at the time of the original wound. Such a case furnishes an example of one of those indirect contusions from gunshot in which the effects differ from those of direct contusion chiefly in the circumstance that a longer time has had to elapse before they become manifest and are rendered obvious to sight.

Gunshot contusion with injury to bone.—On almost every occasion of contusion by a heavy projectile, when a bone is in the direction of the part struck, and is not thickly covered by soft structures, the bone is more or less injured by the blow. It is either compressed and more or less bruised or concussed by the impetus of the projectile. The lesion of the bone may be slight in degree and localised. The injury may merely lead to some effusion beneath the periosteum, which under due rest and treatment may be absorbed, or, under other conditions, it may lead to periostitis of more or less activity, and its consequences. The contusion and attendant shock, however, may be more severe and diffused, may involve the whole substance of the bone, and, under unfavourable conditions of health or other circumstances,

may be followed by inflammation of the endosteum, suppuration, necrosis of greater or less extent, and other consequences which may entail great hazard as regards a limb or even life. The importance of early rest after such lesions cannot be overrated.

Again, the bone may be broken, and the fracture may vary from a single transverse division to another in which the bone is extensively comminuted. Whenever the projectile has been armed with sufficient force to produce fracture of bone, it may be accepted as certain, although there is no open wound of the integuments, that the damage done to the soft parts between the bone and the surface of a limb is very considerable. In exceptional cases of the sort the contusion may be comparatively slight in degree. But more frequently in cases of the kind, however slight the marks of contusion may be on the surface, the damage done to the parts beneath is of a grave character. The pressure exerted has been so violent that it has caused a quantity of blood to be effused, the nervous influence necessary for the maintenance of vitality to be destroyed or greatly blunted, and, owing to the surrounding swelling, the circulation of blood through some of the structures to be very greatly impeded. A condition is then presented in which, if left to themselves, mortification of the crushed structures would follow as an almost unavoidable result, and the hazards of the case be seriously augmented by a communication being established between the external air and the injured tissues.

Open Wounds from Solid Projectiles.

Gunshot wounds in general.—The external distinguishing signs of a penetrating gunshot wound have hitherto been generally manifest enough. The dimensions of the opening have shown whether it has been made by a small-arm bullet, a grape-shot, or a still larger gun-shot; its shape, whether it has been made by a bullet from a rifle, by a fragment of a shell, or an irregular splinter of some secondary missile; while the aspect and condition of the lips of the wound, and of the structures immediately surrounding it, have sufficiently marked it as not being one inflicted by a stabbing or cutting instrument. Still errors have occasionally occurred, for I have known a wound of the head behind the ear attributed to a stab from a bayonet which afterwards proved to be the entrance opening of a bullet. The introduction of the small-bore rifles has led to the openings of entrance of the narrow projectiles used with them, and often those of exit, being so small that in some parts of the body, and under some conditions, their nature may not only fail to be recognised, but occasionally, as instances have shown, they may escape notice altogether although searched for.

Although possessing certain general characteristic features, gunshot wounds, by whatever kind of missile they may have been produced, vary very considerably in appearance, according to different circumstances, some of which have been referred to elsewhere. Especially may be mentioned particular differences in the forms of the missiles causing the injuries; in their speed; in the part of the body struck; in the amount of resistance offered to their onward movement; in the position of the patient relative to the projectile at the time of injury; and lastly, differences in the lapse of time after its infliction at which the wound is seen. I proceed to describe some of the variations in the appearances of gunshot wounds which depend on the influence of the several causes just enumerated.

Heavy projectiles at full speed.—When a massive fragment of a shell, or a heavy shot such as an unexploded shell, while armed with very high velocity, strikes part of the body in a direct line, the missile carries away all before it. If the head, chest, or abdomen be opposed to the shot, a huge gap having a general correspondence with the size of the projectile is effected, the adjoining viscera are scattered, and life is, of course, at once extinguished. If it be part of one of the extremities which is thus carried away, the end which remains attached to the body presents a stump with a nearly level surface of darkly contused, ragged, but still connected tissues, deeply imbued with blood. The flesh presents an aspect of having been torn asunder by a sudden irresistible force. The skin and muscles do not retract, as they would do had they been divided by incision. Particles of bone will be found among the soft tissues on one side of the wound, but the portion of the shaft of the bone remaining *in situ* will probably be found unsplintered and without long-projecting jags or points.[11]

Heavy projectiles at diminished speed.—If the projectile should happen to have glanced off something in its path before striking, and in any case where the force of the shot has been partly expended, the extremity or portion of the trunk may equally be carried away, but the amputation by the missile will be attended with greater dragging and laceration of the parts remaining attached to the body. The integuments will be more ragged; the surface of the wound will be less even; muscles will be separated from each other and hang loosely, offering at their divided ends little appearance of vitality; spiculæ of bone of larger size will be found among them; and the remaining portion of the shaft will probably be found shattered and split for some distance above its principal lines of separation. The injury to nerves and vessels will also usually be proportionately higher and greater. They will be dragged away from their normal connections. A quantity of clotted blood, dark in colour, will be intermingled with all the

torn and contused structures of the injured part. Occasionally it happens, even where a limb appears to have been struck in direct line by a gun-shot retaining immense power, that the parts below are nevertheless not completely detached; they remain connected by a portion of the integuments, on which the bone, reduced to minute fragments, is mixed with the contused muscles and other mashed-up soft parts in a shapeless mass.

Spent heavy projectiles.—If the speed of a massive fragment of shell or heavy shot be still further diminished, so that the missile becomes what has been explained as a 'spent shot,' there will not usually be removal of the part of the body struck by it; but, nevertheless, irreparable mischief will generally be done, owing to the weight of the mass of metal of which the projectile consists. The external appearances presented at the site of injury will be general laceration and crushing of the soft parts, more or less deep and diffused according to the direction and amount of moving power retained by the shot; or they will be confined to ecchymosis, generally extreme, and tumefaction, with but a single wound of limited extent; or even these more conspicuous external evidences of injury may be wanting, and only a slight graze of the surface be presented, notwithstanding the existence of serious internal disorganisation.

Heavy missiles striking obliquely.—Should the shot strike in a slanting direction, the external appearances of the wound will have a general similarity to those described above, according to the velocity of the missile, modified in depth and extent by the degree of obliquity with which it has been carried into collision with the trunk or extremity wounded.

Wounds from smaller shell fragments.—Fragments of shells of moderate size generally produce laceration and separation of the parts against which they strike, the wounds presenting very jagged and irregular edges according to the forms of outline of the fragments. Ordinarily the line of direction in which such missiles move forms a more or less acute angle with the part of the body wounded, and the injury done is rather superficial than deep. When a fragment of shell happens to strike in a more direct manner, and the edge comes first into collision with the part struck, it usually sinks beneath the surface. The wound then, though linear in general character, will have a direction curved in accordance with the curve of the fragment; its margins will be irregularly jagged; and its dimensions will mostly appear to be smaller than those of the fragment itself, from the projectile not having had force enough completely to destroy the vitality and elasticity of the skin and other soft parts through which it has entered, so that these structures partially close around the wound, contract the size of the opening, and not unfrequently conceal the fact that the missile has lodged.

Wounds caused by the projectiles of portable fire-arms.—Important changes have taken place during recent years in the characters and aspects of wounds caused by the smaller forms of projectiles, especially of those produced by bullets fired from rifles. The changes alluded to have become more and more marked as the diameters of the bullets have diminished. The decrease in diameter has been accompanied by other changes elsewhere described, especially by increased velocity and less liability to deformation; and in trying to explain the characters of the wounds inflicted by the bullets referred to, it is not practicable to exclude any one of these attributes. In order to understand the altered characters of certain wounds, it is necessary to trace out the changes by which they have been successively distinguished. Of all the changes that have occurred, none probably will equal in importance those which may be expected to result from the recent introduction of small-calibre rifles and their compound bullets with which the infantry of all the leading Powers of Europe are now armed. It will be of advantage first to describe some of the appearances of the wounds inflicted by the spherical and larger kinds of cylindro-conoidal bullets which are now passing out of use in all regular armies.

Wounds from spherical and cylindro-conoidal bullets at their highest rate of speed.—The projectiles fired from portable fire-arms, when they have force enough to penetrate the body, and when they enter perpendicularly to the surface, or nearly so, leave one or more openings, the external appearances of which vary according to the size, figure, and velocity of the projectiles by which they are caused. The appearances of a wound from a leaden rifle bullet at its highest rate of speed have been occasionally witnessed in cases of suicide. I have had in the course of my military service to examine two cases after death, in which the fatal results were due to self-inflicted gunshot wounds. In both of these instances the projectiles employed were leaden bullets fired from Enfield rifles. I am not aware that any instance of suicide by a compound bullet from a small-bore rifle has been recorded. A soldier, when destroying himself by the discharge of his rifle, mostly stoops over the weapon, presses its muzzle somewhere about his head, and fires it off by means of his great toe, having first removed his boot and sock for the purpose, or by pulling down with his foot some cord which he has previously tied to the trigger. The muzzle is often applied closely beneath the chin. In such a case a circular hole without any puckering or distinct inversion of the marginal skin forms the wound of entrance. There is found to be a positive loss of substance, a portion of skin and subjacent tissue being punched out as it were. The edge of the opening is blackened and burned; if hair be worn, it is singed; and there is dark discoloration of the integument for one or two

inches round. The vertex of the head is shattered; fragments of the parietal and occipital bones, together with small portions of the brain, are carried away with the bullet and scattered about; those bones which are not broken are loosened or separated from their sutures; the great mass of the brain, which has been forced in all directions against the internal surface of the cranium, is rent asunder, but held within it by its membranes; the brain substance is pulpified, blackened in parts, and presents a marked odour of exploded gunpowder; the base of the skull is probably shattered into fragments; the superficial vessels of the face are distended and gorged with blood, and there is evidence of blood having escaped by the nose and ears. These effects are not wholly due to the passage of the projectile, but partly to the smoke and the intensely heated flame from the ignited gunpowder jetting out at the mouth of the fire-arm, and in part also to the expansive force exerted within the cavity of the cranium by the volume of gas resulting from the explosion. The disruptive effects are increased by the violent propulsion of fragments of bone and tissues and wave-like impulse communicated to the blood and mobile substance of the brain itself by the gas and the projectile. The description given is subject to exceptions, for even the perforation of the skull and escape of the bullet may not occur, notwithstanding that the missile has been projected from the rifle by a full charge of explosive powder close to the head, and has therefore been armed with its highest rate of speed at the instant of effecting its entrance. Theoretically, such an occurrence would hardly appear to be possible, but the Museum of Military Surgery at Netley possesses three examples of Enfield breech-loading rifle bullets which had been removed from the interior of the head after suicidal deaths caused in the manner which has just been described. Brief summaries of the histories of these three remarkable cases will be found in the Appendix.[12]

The appearance of the opening will be different if the part against which the muzzle is placed is not soft like the parts immediately below the floor of the mouth. If the muzzle be placed against the true chin, the bullet and combined volume of gas, acting with immense force against the skin, supported as it is here by the maxilla immediately above, will cause a large lacerated gap to be exposed at the wound of entrance. This is due to the rebound from the hard subjacent bone, together with lateral diffusion, of part of the volume of gas. A pistol pressed and discharged against the skin covering a rib will from the same cause make a very large opening, much larger than the opening of exit, should the bullet have force enough to pass completely through the chest. Other effects follow in each case from the shattering of the bone struck by the projectile and the impetus given to the fragments.

Similar wounds from bullets near to, but not touching the skin.—If the muzzle of the rifle be not actually pressed against the chin, but is held a short distance, not more than a few inches, away from the skin covering the soft parts within the horizontal branches of the lower jaw, then the condition of the wound of entrance is widely different from that above described. In a case of this kind the wound of entrance will be large, ragged, and excavated, while the torn and denuded tissues will be more or less scorched, blackened by smoke, and studded with grains of unexploded powder. The force of the gas escaping from the rifle exerts a destructive power, not only in the immediate wake, but also around the sphere of the projected bullet. The dimensions of the gap effected in the soft tissues, and the blackening around, will vary according to the circumferential limits of the propelled gas which is first forced against them, or, in other words, according to the distance from the wounded part at which the rifle has been discharged.

Flesh wounds from bullets fired from long distances.—When a projectile such as an Enfield or Martini-Henry bullet has been discharged from a rifle at a distance of several hundred yards, the following have been the usual early appearances of the wound of entrance when the parts through which it has entered have not offered any appreciable resistance to the passage of the missile. An opening about the size of the projectile, but not unfrequently appearing rather smaller, is presented to view. It is generally more or less circular in shape, but sometimes more elongated in one direction than in the other, with the edges a little serrated, undermined, puckered, and flabby. The appearance of the aperture varies in some respects according to the site of the part penetrated, as well as to differences in degrees of velocity. Occasionally a single flap of integument is found at the opening, held by a small isthmus of skin to a part of its margins; sometimes the opening is bounded by two or three loose flaps, which, on being lifted up, approach at their free ends towards its centre. With both the spherical and the cylindro-conoidal bullet, when they are travelling at a very high rate of speed, and strike point-blank, not obliquely, the opening consists of a vacant circular space, corresponding very closely with the circumference of the projectile, and when in appearance smaller, still readily admitting a bullet of the same size as the one by which it was made. This opening represents the site of a portion of integument which has been punched out, as it were, and carried away by the bullet. With a certain amount of diminution of speed in the two bullets, there will be less loss of substance with the conoidal than with the spherical bullet; and if the speed be still further diminished, though still sufficient for the two bullets to penetrate and pass deeply into, though not to perforate, a part of

the body, there will apparently be no loss of substance with the conoidal bullet, but the opening will be formed simply by division and separation of the edges of the rent skin; while with the round bullet there will still be a portion of skin carried away before it. In each of the forms of opening above named, the whole wound usually presents at first a slightly inverted aspect. There may be darkening of the marginal skin of a livid purple tinge, from the effects of destructive contusion, increased in depth of colour sometimes at the edge by dislodgment of a little unexploded gunpowder which had been adhering to the bullet; while occasionally the edges of the wound will appear flaccid and pale, as if the bullet, at the same time that it deprived them of vitality, had also pressed out all the blood from their capillaries. The margin of the opening, again, will be surrounded by a violet-coloured marking of the neighbouring skin, varying in depth of tint and extent according to the amount of contusion. Outside this, again, will usually be a bright pink blush indicative of capillary injection. The evidences of contusion are always most marked at the wound of entrance when there are two openings. The peculiar appearances of the contusion surrounding the openings of such bullet wounds, the extremely severe contusion of their lips, with the regular gradation of diffused tint as it shades off into the healthy skin beyond the sphere of influence of the projectiles, are very characteristic of such injuries, and readily distinguish them from contused wounds inflicted by ordinary blunt instruments.

The following appears to be the explanation of the different conditions which result from the penetration of spherical and conoidal bullets.

With a spherical bullet at its highest rate of speed, a cap of integument closely corresponding in dimensions with the front of the bullet up to its equatorial limits, or nearly so, is at once cut out and carried away before the bullet. With less speed only a smaller segment of the bullet exerts this concentrated punching out force on the skin immediately opposed to it. The rest of the face of the bullet, acting more and more obliquely until its equatorial circumference is reached, stretches the skin before it so as to form a cup-like depression, within which the ball glides onwards, at the same time slightly tearing and distending the edges of the hole whence the part had been punched out, sufficiently to permit the whole projectile to pass through to the deeper structures. If the skin impinged upon happen to be so placed relatively to the projectile as to be capable of exerting its elastic quality evenly on all sides, the margin of the hole is left entire, though probably seriously compromised, or even devitalised, by the severe stretching and contusion to which it has been subjected. If, on the other hand, the skin happen not to be free,

but is intimately connected with neighbouring fascia, then the margin of the hole will probably be left with a torn fringe, or be divided into flaps.

With a conically pointed projectile a similar action takes place, but the opening left is necessarily smaller, owing to the obliquity of the surface presented to the skin being greater, and the diameter of the elongated bullet being less. No skin may be carried away when the speed is much diminished, because time is given for the opening to be made by stretching and piercing, as it were, the opposing tissues.

Wound of exit.—Should the bullet have passed out, the wound of exit will probably be larger than the projectile, sometimes much larger, but generally with little or no actual loss of substance. The integument at the point of exit has been torn asunder, not opened by having a part punched out, as usually happens at the point of first impact of the projectile.

Different appearances of wounds of entrance and exit.—The differences between the appearances presented by the openings of entrance and exit, to whatever extent they may be exhibited, are the more easily recognised the earlier the wound is examined. The aperture of exit usually appears more irregular and torn than the wound of entrance, with its edges somewhat everted, and occasionally some protusion of small particles of subcutaneous fat or shreds of muscular tissues. The appearances are due partly to the velocity of the bullet having been somewhat lessened by the opposition it has met with while passing through the several structures which it has successively traversed; partly to the structures at the place of exit having been forced *away from* their supports, instead of *towards them,* as was the case at the wound of entrance. They are more obvious when a spherical bullet has caused the injury than when it has been inflicted by a cylindro-conoidal bullet: indeed, with the latter, when of moderate size, and it has passed apex forwards in a direct line at full speed through soft tissues only, when therefore there has been scarcely any difference between its rate of movement on going out of the body as compared with its rate of movement on entering, when it has neither carried a foreign body nor a fragment of bone or any other internal substance before it, under these circumstances it is often very difficult to distinguish the wound of entrance from that of exit by their respective appearances, even in the early condition of the injury.

Relative sizes of wounds of entrance and exit.—The *relative* dimensions of the two openings of entrance and exit in perforating wounds limited to the softer structures of the body vary under particular circumstances. As a general rule, at ordinary medium rates of speed the entrance opening of the projectile is rather smaller than the opening of exit; but when the

projectiles are armed with very high rates of velocity, scarcely any difference in size between them will be noticeable.

When the wound of exit of one of these bullets which has only traversed soft tissues is much larger than that of entrance, it will generally be found that other substances besides the bullet have been carried through it. In one example at Netley of a wound of the abdomen by a Chassepôt bullet inflicted during the war of 1870–71, with a large opening of exit, a mass of omentum has passed out with the projectile through the body of the rectus muscle, a thick layer of fat, and through the integuments.[13] As a general rule, however, where soft parts only have been traversed by a cylindro-conoidal bullet, however much the structures in its track may have been stretched and torn, the tough and elastic skin is able to keep nearly all, excepting the bullet itself, from passing through it.

The *actual* sizes of the openings of entrance and exit are liable to be modified by many circumstances, some of which appertain to the projectile and its direction at the moment of impact, some to local conditions appertaining to the part struck. Remarks on these will follow presently.

Circumstances which modify the appearances of wounds of entrance.—The position and state of the skin at the moment of being penetrated by a projectile will sometimes modify the appearance and size of the wound of entrance, even when it has entered perpendicularly to the surface. If the integument belong to a part where soft tissues abound, and where it is subjected to occasional distension and relaxation, and the projectile strike the surface with only a moderate penetrating force at the time the integument is on the stretch, then the opening will appear very small with reference to the projectile, in the relaxed state which the parts will assume shortly after the infliction of the injury. The opening will appear to be still smaller after infiltration and swelling of the surrounding tissues have occurred. A similar projectile, if it impinged upon skin overlying bone, as one of the ribs, would cause a far more extended wound of irregular outline; for the skin would be crushed and the elasticity of its edges impaired between the direct impact of the bullet on the one side, and the resistance of the bone beneath on the other. If, on the other hand, it happen to strike and penetrate between two ribs, the direction in which the skin becomes stretched, owing to its position before yielding for the passage of the bullet, may cause the wound of entrance to assume the character of an ellipse with its long axis running parallel with the ribs above and below, or even of a mere slit. And so in other parts of the body, the direction of the principal fibres of the superficial fascia with which the skin is connected, and other local circumstances, may modify the apparent form and direction of the opening made by a projectile on entering.

Small-bore armoured bullets.—(*a.*) *Wounds of entrance.*—When one of these projectiles, with its form intact, strikes a part of the body perpendicularly, or nearly so, and the part is either uncovered by clothing, or covered by materials offering little resistance, the opening by which the projectile has entered approximates in size and outline to the circumferential limits of the bullet which has made it. A gap is presented at the part, for the portion of skin struck by the projectile has been stamped out. The apparent size of the opening will vary in some degree, owing not merely to the state of the skin at the point struck, but also to its relations with neighbouring structures, particularly as to the elasticity of the skin surrounding the opening, whether it can be exerted or otherwise. In an accidental wound by a ·303-inch Lee-Metford bullet, the entrance opening was described by Surgeon-Captain Marsh, who examined it an hour after infliction, as 'looking like a clean punched-out bit of skin.' The bullet had struck the man in the latter part of its course at a distance of 2560 yards from the rifle, and therefore would intersect the plane of the thigh with its long axis more or less inclined toward it, and thus the opening, instead of being circular, would be elliptical. Surgeon Marsh mentioned that it was 'slightly oval in shape, $\frac{3}{8}$ths of an inch one way, and $\frac{2}{8}$ths in the other.' No doubt a slight manipulation of the adjoining skin would have shown some slight differences in the dimensions stated.

(*b.*) *Wounds of exit.*—If the projectile should take a straight course through a part of the body at a very high rate of velocity, there will often be so great a similarity between the wounds of entrance and exit that it may be difficult to distinguish one from the other from their mere appearances. Occasionally, even with such a high degree of speed, the exit opening may be a gaping one, from some of the deeper structures having protruded through it. If, however, the velocity has been partly expended, then, instead of a small circular opening, the exit may appear as if the skin had been rent asunder in two or more directions. In the case of the Lee-Metford bullet wound before mentioned, when from the distance at which the man was struck the force of the projectile must have been considerably lessened, the exit wound at the back of the thigh was stated to be a transverse slit in the skin, $\frac{5}{8}$ths of an inch in length, without any loss of substance. The integuments, after having been thrust outwards and torn asunder, and having allowed the projectile to escape, must have retained sufficient elasticity to resume their former position.

Wounds with so-called hydraulic pressure.—Among wounds inflicted by rifle projectiles travelling at high rates of velocity are some which are attended by such great local destruction and so much surrounding disturbance that, owing to the difficulty in finding a satisfactory explanation of the amount of damage done

by attributing it to the simple impact of the projectile, efforts have been made to solve the problem by supposing it to be caused by hydraulic pressure. The wounds under notice form a most striking contrast with other wounds produced by the same kinds of projectiles, fired apparently under precisely the same conditions, in which simple perforation only has occurred. They have been met with in experiments with small-bore hard-mantled bullets, just as they have been in practice with the softer and larger leaden bullets which have been in use for the last twenty or thirty years.

Experiments for testing hydraulic action.—Numerous experimental trials have shown that when a bullet is fired into a tin vessel filled with water, either completely closed, or so nearly closed that the water meets with difficulty in escaping from the vessel, the pressure exerted by the bullet is communicated to the whole mass of fluid, just as happens in an ordinary hydraulic press, so that, if the containing vessel consists of parts which have been merely soldered together, some of these parts are apt to be torn away, and the whole vessel to be bent and more or less deformed, according to its power of resistance, from the internal pressure. The propellant action of the projectile joins with the hydraulic action, so that the greatest evidence of pressure will probably be exhibited in the direction of the path of the bullet, and the side of the vessel opposite to the opening of entrance of the projectile may be most distorted; but at the same time, in concurrence with the known slight compressibility of water, the pressure will be communicated to the whole of the fluid contents and diffused over all the interior surface of the vessel. If the apex of the bullet should be compressed and flattened in the act of penetrating the side of the vessel, although the movement of translation, and therefore the force, must be lessened in the production of this change, a greater surface will be presented to the fluid contents of the vessel, and a proportionally increased pressure exerted upon its containing walls. Similar experiments have been tried on fluids contained in bladders filled with water, and rendered so tense that no further stretching of their substance could take place, and similar disruptive results have ensued. It is upon deductions drawn from such experiments, and from the known fact of the structures of the human body being all very largely supplied with blood and other fluids, that the theory of hydraulic pressure being the destructive agent in the wounds under notice has been chiefly based.

Objections to the theory.—Some objections to the views regarding hydraulic pressure in wounds occur on the first consideration of the subject. The conditions are very different between a closed and rigid metallic vessel, or one so nearly closed that the fluid can only escape with difficulty and by slow degrees from a narrow outlet, and the soft and yielding structures of the human

body, although they are largely charged with fluid. A similar difference exists, though not in so marked a degree, between a tightly closed membranous sac like a bladder distended by fluid on being subjected to the impact of a projectile armed with enormous force. In the former instances the fluid at the time the impulse of the shot is impressed on it is confined within fixed limits and under strict restraint, the entire body of water offers resistance to the impact of the projectile, and this resistance is only overcome by the expenditure of immense force on the part of the projectile; in the latter, the scattered fluids are practically unconfined, and, like the tissues of which the blood largely forms part, are incapable of offering the resistance to the shot which is an essential ingredient in the manifestation of hydraulic action. In the experimental trials made with the rigid tin or wooden vessel filled with water and fired into, the effects of hydraulic pressure were truly witnessed; for whatever might be the sectional area of the bullet employed, and whatever the pressure exerted upon the fluid at the part where the bullet effected its entrance, that same amount of pressure was exerted by the whole of the fluid in an outward direction upon every corresponding areal portion of the interior surface of the vessel. These conditions cannot be fulfilled in any part or organ of the human body, so that the action of hydraulic pressure, in the strict sense of the term, cannot take place, and to use it in any other sense is only calculated to mislead.

Different aspects of wounds not readily explained in some instances.—It is confessedly difficult to give full explanations of some of the injuries that may be met with from modern rifle projectiles that are free from all objections—so various and so complex are the elements concerned in the questions to which they give rise. I have witnessed in experiments with the Swiss Rubin bullet on horses which had been killed immediately before the trials were made, such destruction effected, that, judging by its aspect and areal extent, it rather appeared as if it had been caused by some powerful explosive agent than a small and narrow projectile. I have seen the large viscera of the chest torn asunder and portions of them literally mashed, and the strongest part of one of the strongest bones of the animal—the trochanter major of the femur—after being struck, present a crater-like cavity into which the fist could be thrust, thickly coated with pulverised bone detritus, while the bone upwards to the head and downwards in the shaft was split into fragments. In another instance a small entrance opening was observed, which led to a cavity in which muscular and other tissues were torn up and crushed, bone comminuted, and, beyond these, a widely lacerated wound of exit, through which strips and fragments of the various structures that had been rent asunder were protruding. The damage done was manifestly irretrievable. In all these

instances it seemed to me doubtful whether the great injury effected had not been due in some measure to the copper covering of the Rubin bullet becoming stripped off and broken into pieces. The copper covering was found in a few instances to be torn away from the core and to be broken up into small and sharp angular fragments mixed with particles of lead. On the other hand, I have witnessed in experimental trials at Carlsruhe, in Baden, the steel-mantled bullets manufactured in the Lorenz factory fired in a succession of instances through animal tissues without any such effects being produced, whereas leaden bullets of the same forms and sizes, and fired by what were stated to be similar charges of gunpowder, produced great laceration and destruction. The Lorenz bullets, after being fired through such objects as a suspended bullock's heart, and other pieces of muscular structures of different sizes, perforated the thick front of a long wooden box, and were received in a bed of sawdust, whence they were removed, quite free from deformation. They left only simple punched-out openings of entrance and exit, with a regular track between them, in the objects that had been respectively perforated. I attributed the characters of these perforations at the time I witnessed them to the hardness of the steel envelope of the Lorenz bullet, its polished surface, and the close and intimate connection between the envelope and the core. Against the sufficiency of this explanation, however, must be stated the fact that I assisted at a series of trials in December 1888 of small-bore projectiles in which the ferro-nickel envelope was soldered to the core in half the number, and unsoldered, though closely applied to the core, in the other half—one of the objects of the trials being to ascertain if there were any marked differences in the features of the wounds inflicted by the two kinds, the soldered and unsoldered bullets. At the conclusion of the trials it was agreed that the wounds produced by the unsoldered could not be distinguished from those produced by the soldered bullets. The wounds were as severe with the one kind of bullet as with the other.

Undulation of soft tissues.—When a soft substance, approaching to a state of fluidity like the brain, and free to move as the brain is in the cerebro-spinal fluid, is penetrated by a projectile armed with high velocity, an undulatory movement is communicated to its substance. The wave-like motion will be generally diffused, but will follow certain directions with more intensity than it will in other directions, depending upon the path pursued by the bullet and other local circumstances. When President Lincoln of the United States was assassinated by being shot in the back of his head, the bullet followed a direction in the brain to one side, and at the same time communicated a vibratory movement in the direction of the orbital plate on the other side

of sufficient force to cause its fracture.[14] Other similar examples of concentration of wave impulse on particular points might be quoted. An action of the kind described is very different from the action of hydraulic pressure, the essential principle of which is that the liquids concerned transmit pressure equally in all directions.

Influence of special qualities in particular tissues.—In studying the action of projectiles on animal bodies, the special qualities of the various anatomical tissues of which they are composed must always be taken into account, as well as the circumstances under which the animal is placed at the moment when a projectile is brought into collision with it. It is obvious that the capacity for lessening the quantity of motion there may be in a rifle bullet at the time it strikes an animal is very different if the part struck be a dense and hard bone from what it is if it be a soft viscus such as a spleen or liver, an elastic structure such as the skin, or a mobile but resisting tissue such as a tendon or aponeurosis. The amount and character of the opposition will vary in each of the instances mentioned. Again, in estimating the passive or resisting force of an animal, its size and weight, its condition of rest or action at the moment of being hit, must exert some influence on the effect produced. The conditions are very different if an animal such as a massive horse be suspended and is the object fired at, or if it be merely a solitary viscus like a heart which is suspended and aimed at. In the instance of the horse, the force of passive resistance which will be opposed to the bullet is probably very considerable by comparison with the resistance offered by a heart suspended separately. In the latter case the passive force opposed to the energy of the bullet will be practically of no account. The circumstance of the body being in motion or at rest will make some relative difference in the resisting force opposed to the bullet. In the instance of a modern rifle bullet, specially constructed to ensure the highest penetrative capacity, its active force at a high rate of velocity is so enormous that the passive force opposed to it under the various circumstances mentioned is hardly recognisable, for the opposition is overcome without any display of resistance. The relative differences in the amount of passive force put forth must, however, still exist, and under some conditions, as when the velocity of a projectile is sufficiently reduced, will become more or less manifest in the resultant effects.

Probable cause of some wounds ascribed to hydraulic pressure.—When from any cause it happens that the penetrative capacity of a rifle bullet moving with very great velocity is not turned to its full account at the same time that a certain amount of effective resistance is offered to its onward progress, as, for example, when a bullet by some means is diverted from its

normal progressive movement in the line of its long axis, so that it ceases to travel strictly apex forwards, while its movement of rotation continues on that axis, it is obvious that in overcoming the passive force opposed to it, it will part with more of its momentum than it would have lost if it had preserved its normal line of flight. The bullet presents a broader front to the opposing tissues, and in this respect is somewhat like a soft bullet the apex of which had become flattened. If momentarily held or entangled among any of the fibrous tissues, there is more resistance to overcome, and in the same instant more loss of momentum. Whatever may be the amount of momentum lost by the bullet, that amount is gained by the substances opposed to it. The projectile communicates a portion of its own active force to whatever is momentarily brought into collision with it. If the bullet be travelling at its highest rate of velocity, and it confronts parts which are largely charged with blood or other fluids, each particle of fluid becomes itself a projectile armed with a very considerable amount of active force. The powerful stroke that may be derived even from fluids is familiar to every one. Water is as resisting in its nature as the substance of a steel-mantled projectile; but under usual conditions the almost unlimited divisibility and mobility of its particles—its fluidity—oppose manifestation of the fact; under suitable arrangements, however, water can be made to act as a borer of the hardest rock. When a heavy projectile is shot into a body of water, part of its momentum is communicated to a column of the fluid which is caused to ascend to a very considerable height in opposition to the force of gravity and the resistance of the air. If it be bone which is encountered, its substance is crushed, and each fragment, whether small or large, becomes charged with an immense amount of active force, which it in turn expends on some of the surrounding tissues.

The momentum thus secondarily imparted is derived both from the progressive motion and the whirling motion of the bullet, as well as from these two motions compounded with one another. Hence the particles of fluid and the solid fragments are driven practically in all directions, though with more force in some than in others. Some will be so acted upon by the projectile force of translation that they will be driven forward; others will be whirled around like missiles thrown from a slinger's thong by the centrifugal influence of the force of rotation; those acted upon by both forces in combination will follow courses practically in all directions according to the relative magnitudes of the two forces by which they are impelled; tissues offering the least or no resistance will be disintegrated and resolved into a state of pulp. An indication of the probability of the wounds which are accompanied by extremely diffused local damage being chiefly due to

some special resistance having been offered to the projectile, and to the enormous force which has been instantaneously expended in overcoming it, is afforded by the fact that the cases in which it occurs, when only soft tissues have been encountered by the bullet, are quite exceptional, and only occur within very limited ranges; while when bone happens to be struck, such wounds are not only met with frequently, but also over a range of much greater extent.

Owing to the immense amount of force derived in the ways mentioned from projectiles moving at high rates of velocity, by the dispersed fluids, bone grit, and larger bone fragments in certain wounds, the destructive effects are occasionally so widely spread and so extreme, that one can hardly be surprised at the aspect of the damaged parts resembling in a strong degree the condition which might be expected to result from an explosive projectile which had burst in the midst of the tissues and had caused the injuries presented to view. Hence some surgeons have been led to describe such wounds as 'explosive wounds,' and the action of the projectiles by which they have been produced as 'explosive action.' As they are only met with over the area within which the projectiles retain very high rates of velocity, the range of this area, or zone, is frequently described as the 'zone of explosive action.' The term seems to be less open to objection when used in describing the different kinds of actions of projectiles than the term 'zone of hydraulic pressure,' which is largely used among Continental surgeons; for the former term, that of explosive action, cannot be interpreted in any other way than as an expression of resemblance; while the term hydraulic action indicates the presence of a cause which, to say the least, is certainly of very doubtful existence under the circumstances described.

Zones of special action of rifle bullets.—Efforts are occasionally made to systematise the action of rifle projectiles by dividing the injuries which result from them into special groups according to their leading features and the distances at which they are respectively produced. All artificial divisions of the kind must be more or less imperfect, as the velocity, and therefore the force of a projectile, lessens gradually throughout the whole range of its flight, and the modifications in the characters of injuries which are due to variations in the force possessed by it at different parts of its course must pass insensibly from one to another in corresponding gradation. There can be no constant diversity between the characters of the wounds that may be produced by a shot on either side of any given boundary-line.

With the foregoing reservation it may be accepted as being occasionally convenient for purposes of description to speak of wounds according to their most obvious features in certain

portions of a bullet's trajectory—a portion over which its highest rate of velocity is closely maintained; a second, in which the velocity, though less, is still very high; a third, in which the velocity is still further diminished; and a fourth, in which the retained velocity is approaching its minimum. In dividing the sphere of action of a rifle projectile, so far as concerns the general characters of the wounds it is liable to cause, it is ordinarily separated into the following four zones, in agreement with the different degrees of velocity just mentioned, viz. (1) the so-called zone of explosive action; (2) a zone in which the action, though not explosive, is intense, so that the wounds are attended by loss of substance; (3) a zone in which wounds are characterised by laceration of the tissues, but without loss of substance; and (4) a zone in which only contusion is exhibited. It is at once obvious that in making such a division of the sphere of action of a rifle projectile, the extent of each zone will vary with the kind of rifle bullet employed, and especially with the initial velocity imparted to it, the resistance it meets from the air in its flight, and other such circumstances. Generally speaking, the higher the rate of muzzle velocity impressed on the bullet, and the more suitable its form and other qualities for overcoming the resistance of the air, the more extended will be the so-called 'zone of explosive action,' and the greater will be the distances to which the three remaining zones will be removed. The zone of simple contusion will hardly exist at all in the new narrow armoured projectiles, their capacity for penetration being so very largely developed

Later appearances of gunshot flesh wounds.—If inflammation and its attendant swelling and vascular excitement should have supervened, as ordinarily happened in former days, the appearances would of course no longer agree in all particulars with those which have just been described; and if the wound were examined a week or so after its infliction, especially when a spherical bullet or one of the larger sized cylindro-conoidal projectiles had struck with an average amount of force, not at its highest rate of velocity, and when it had passed out unaltered in form, the appearances which characterised the wounds of exit and entrance at the commencement frequently would be found reversed. The different features presented at these two periods of time probably led to some of the discrepancies in the descriptions of different observers of the relative sizes of the two openings. The wound of entrance would usually at this latter date appear to be the larger, and there would probably be more fulness and protrusion from it than at the wound of exit. The tissues which first received the stroke of the bullet, and which were therefore most extensively contused and deprived of vitality, would now be in process of being cast off in a sloughy condition; the tissues through which the bullet last passed, and which were

therefore least injured, would now be assuming a clean and healthy aspect.

In the instances in which direct wounds through soft tissues without complications occur from the action of modern narrow armoured bullets, so long as they are maintained aseptic, very little difference will be noticeable between the wounds of entrance and exit during the whole period of repair. The trifling loss of substance at the opening of entrance will be filled up by granulation with scarcely any appreciable discharge, while the track and wound of exit will probably become closed almost insensibly by a process of adhesion.

Conditions on which the appearances above named depend.—The foregoing description refers in the first part to the appearances presented when a leaden bullet enters alone, without any portion of clothes or other substance being carried in front of it, and when it preserves its shape throughout its course in the wounded part. Should some extraneous substance enter with the projectile, the appearance of the wound of entrance and its relation to that of exit will be changed in certain respects, as will be noticed presently. Should the projectile after entering become spread out or otherwise altered in form, as often happens when a leaden bullet strikes against and glances over a strong resisting bone, the general conditions will still exist as described, but obviously the relative magnitude of the wound of exit will be increased in proportion to the increase of dimensions which has taken place in the projectile itself. As regards the narrow armoured projectiles of the present time, the nature of the metals which constitute them, their hard and smooth surfaces, with their little liability to deformation, prevent effects being produced by them similar to those which usually attended the action of the softer leaden bullets.

Wounds from shrapnell bullets.—The wounds inflicted by hardened bullets from shrapnell or canister differ in no respect in their nature or appearances from wounds produced by musket or rifle shot of nearly similar sizes and weight; but, owing to the less velocity of such shot at starting, the wounds are not often so severe as those caused by direct small-arm projectiles. Soldiers wounded by such bullets are usually struck by them after much of their momentum is expended, so that these projectiles seldom have force enough to make a wound of exit. A serious feature connected with such wounds is the liability to several bullets taking effect at the same instant, owing to the mode of their discharge from the primary projectile.

Appearance of a wound from a leaden bullet, with fracture of bone.—If such a bullet, instead of causing a simple flesh wound, should meet and fracture a bone in its passage, especially if the fractured bone is situated near the surface towards which the

projectile has taken its course, and is not covered very deeply by muscular tissues, then the wound of exit usually differs greatly in appearance from the wound of entrance. It no longer corresponds in general outline with that of the bullet, but presents flaps of irregularly torn skin and subcutaneous tissue, the length, number, and direction of the rents varying according to the shapes and number of the splinters which the bullet has thrust forward and pushed aside as it forced its way out from among them. The bullet, too, under these circumstances, is probably considerably flattened and altered in shape, or is broken into two or more fragments, and thus adds to the difference in character between the wounds of entrance and of exit. Although the appearances just described apply generally to all wounds from leaden bullets, complicated with fracture of bone, there are special peculiarities in the appearances of some wounds in which particular bones are involved, such as the ribs, the bones of the cranium, and others. These can only be properly discussed when the injuries of the particular regions in which the bones are situated are considered.

Similarly complicated wounds from narrow armoured projectiles.—Two typical kinds of fracture are apt to occur when bones have been penetrated by these projectiles, one in which the bone or bones struck are enormously comminuted, the other in which the bone, either a long or flat one, is cleanly perforated, but usually with more or less fissuring extending from the perforation. In the former case the same contrast between the wounds of entrance and exit may be presented as is described in the preceding paragraph; in the latter, the wounds may be closely similar in appearance. A third kind of fracture, only exceptionally met with, is one in which a narrow small-bore projectile has happened to strike the shaft of a bone tangentially, merely grazing the surface, but at the same time has concussed the bone with such violence that a transverse fissured fracture of its substance results. The occurrence of the fracture in this case will not modify in any way the aspect or condition of the wound of exit unless the collision has happened to change the axis on which the bullet is travelling. The quality of the metal with which the narrow projectile is armoured, especially its relative hardness, appears to exert some influence on the manner in which a bone is fractured, whether it be a flat or long bone, its shaft or articular extremity, and thus indirectly affects the relative aspects of the wounds of exit left by bullets in the integuments.

Numerous trials have been made in order to determine the differences in the leading features of fractures produced in bones by narrow projectiles as compared with those which resulted from the bullets of larger diameters which preceded them, and able reports have been published by various eminent surgeons of different countries on their results. These reports are mostly

accompanied by excellent drawings illustrative of the kinds of fracture produced at different distances and in different forms of bones. A list of published reports in which such illustrations may be seen will be found in the appendix.[14] An examination of the several reports sufficiently shows that when small-bore armoured bullets strike resisting bones while armed with very high velocity, that is, within relatively short ranges, there is very little difference in the great amount of comminution of bone and general damage produced by them and the ·45-inch bullets in previous use, the main difference between them being that the destructive effects of the narrower bullets are met with at distances considerably beyond those at which they result from the bullets of wider diameter. The damage done by the narrow bullets at medium ranges to the shafts of bones is always very great, but has been generally observed to be less, that is, perforations are accompanied by less amount of fragmentation and splintering, and less extent of fissuring, than in wounds inflicted by the bullets which were in general military use before the introduction of the small-bore rifles; while at very long ranges, at which a greater amount of velocity and far higher penetrative power are preserved by the narrow bullets, the comminution and splintering are generally greater from the narrow than from the broader projectiles, as might be anticipated. When the bones are penetrated near their spongy articular extremities, the canals bored through them by the narrow bullets, both at middle and remote distances, are usually more defined, more free from splintering, and show fewer and shorter fissures extending from them than corresponding fractures in the shaft, thus differing considerably from what frequently occurred when the leaden rifle bullets were the sources of perforating wounds in the situations mentioned. At the same time, many exceptional cases are met with in which the epiphyses of long bones are found extensively shattered, the fragments being only kept together by their periosteal connections.

Wound of entrance larger than the wound of exit immediately after the injury.—There are occasional cases where the wound of entrance is larger than the wound of exit directly after the bullet has passed through a part of the body. It may be so from the weapon having been discharged so close to the person that the wad or some gas has been carried into the entrance wound with the bullet; or from the projectile, on entering, carrying in front of it a portion of some of the coverings of the part wounded, such as a piece of leather or cloth, and then passing out without taking with it either this additional substance or any portion of the tissues through which it has cleft its way. The same thing will occasionally happen when the bullet has entered a part where the integument covers a superficially placed bone, and when it takes its course afterwards through muscular tissues,

and makes its exit at some part remote from the place of entrance. Thus a bullet entering over the olecranon and passing out in front of the upper part of the arm, or entering over the malar bone and passing out through the soft parts of the back of the neck, will present a larger wound of entrance than of exit. But very frequently the wound of entrance is only larger than that of exit in appearance; and this occurs when the projectile has struck the surface slantingly, so that a portion of the skin and subcutaneous tissues have been shaved away on one side before the projectile has passed through the superficial fascia. There is here, strictly speaking, a rasing wound on one side of the true wound of entrance; for the true entrance wound is, of course, the commencement of the track of the projectile through the deeper structures. A wound of this kind leaves a peculiar scar, in which the difference between the part belonging to the superficial injury, the rasing wound, and that closing the real aperture of entrance is always very strongly marked.

In medico-legal investigations concerning gunshot wounds, it sometimes is still a matter of great importance to decide which of two wounds made by a projectile has been the entrance wound, in order to establish the direction from which a bullet has been fired, and the evidence of surgeons has often been closely sifted in courts of law on this point; but to military surgeons, more especially from circumstances connected with recent projectiles, it has become a subject of much less practical interest than it formerly was. When the indirect and tortuous course of a bullet was the rule rather than the exception, a knowledge of the spot at which it had entered was often useful in diagnosing the mischief it had probably committed in its passage, and in determining the part of the wound where foreign substances might be supposed to have been carried and to be lodging. When the track of the bullet is nearly in a straight line, as is now the rule, such information cannot be looked for from knowing the relation of either opening to the course of the projectile.

Bullets fired on level ground striking the surface with a parallel or very oblique direction.—The appearances above described, as already mentioned, are those produced by bullets when they are brought into collision perpendicularly, or nearly so, to the surface wounded. If a bullet penetrate the surface with only a slight inclination, the opening made by it will be elliptical instead of being circular. Should, however, it strike at an acute angle, the extent and appearances of the wound may vary very greatly. If the bullet touch or strike while passing in a direction almost parallel with the surface, constituting what is termed a 'rasing shot,'[15] the wound may have an appearance as if a line of integument of the width of the projectile had been planed off. If it penetrate more deeply, a furrowed excavation, rendered broader

than the width of the projectile by the elasticity of neighbouring structures, may be presented to view. The length of the wound in either case will depend upon the outline of the surface with which the bullet has been brought into collision; being short if it happen to have struck across a part with very convex outline; longer if the surface, as in a superficial wound of the back, approaches nearer to a level. As in other gunshot wounds, the edges often appear irregularly torn, and more or less extensively ecchymosed, according to the velocity with which the bullet has traversed the substance of the rased structures.

If the bullet strike a little deeper than the surface, and in such a way that a portion of integument is momentarily forced up in front of it, instead of the open furrow, a tunnel-like wound, with a thin covering of integument over it, may be inflicted. The appearance of the integument covering the tunnelled opening varies according to the depth of subjacent tissue, but is usually left pale and livid.

Ricochet and deflected bullets.—A projectile which, after striking the surface of the ground or of water, bounds onwards with more or less velocity, is usually described as a *ricochet shot*. Bullets which strike a person after ricochetting, or after lateral deflection from a substance offering much resistance, as the side of a rocky ravine, a brick wall, &c., occasion wounds which require notice, as they often differ materially in their aspect and characters from wounds by bullets of the same description which have struck the body direct. It has been already explained that the modern compound projectiles are not as subject to changes of form, or to being broken up into fragments, on striking hard substances, as the leaden or hardened lead bullets were; but they nevertheless occasionally undergo important alterations, such as are shown in figs. 35 and 36, which materially affect the characters of the wounds that may happen to be inflicted by them. These effects are principally due to the difference in quality of the metal forming the envelope, and of that composing the core enclosed by the envelope, together with the nature of the connection, especially with respect to the completeness of the union existing between the two. When an armoured small-bore bullet is fired with very great force in a direct line against a sufficiently opposing substance, as when a bullet, moving at very high velocity, has its movement completely stopped by striking an iron target perpendicularly to its surface, the envelope is separated from the leaden core, and the core is broken up into numerous small flattened fragments and irregular particles. But when it strikes a hard substance, like a stone lying on the ground, and is reflected from it, so that only a portion of its force is expended in the collision, the bullet usually undergoes no more than a partial separation of the core and envelope. This occurs with more or less change of form, or dis-

tortion, of the entire projectile in some instances, while in others there is simply a limited superficial flattening, or perhaps grooving of the surface of the bullet, either in front or at the sides. The projectile after deflection retains part of its movement of translation, the amount varying according to the angle at which it has struck the opposing substance and the extent of opposition it has encountered. When the projectile retains force enough to perforate the human body, under these circumstances, of course, neither the openings of entrance and exit, nor the track will agree in their characters with those made by a bullet whose regular course had not been interrupted, but they will accord with the particular change of shape to which the deflected bullet has been subjected.

The angular direction which the entrance and track of a wound from a ricochet bullet may follow is quite uncertain, because it is a mere matter of accident what may be the inclination presented by the shingle or stone on the ground to the bullet at the moment of collision, and therefore what may be the angle at which the projectile may be deflected from it. A ricochet bullet has been known to fly almost directly upwards to a considerable height in the air, and to inflict a severe wound on the head of a man sitting close to the spot at which it struck the ground.[16]

Varieties in number of openings made by bullets.—The *number of openings* made in the body by one or any other given number of small projectiles is subject to several variations.

Number of openings usually made by bullets.—A bullet ordinarily causes either one wound, as when, after entering, it lodges, or happens to escape again by the wound of entrance; or two wounds, one being the opening of entrance, and the other that of exit of the projectile. Most probably with the small-bore armoured projectiles the occurrence of a single opening, with lodgment of the missile, will be exceedingly rare.

Wounds in two places: are they wounds of entrance and exit?—It has sometimes been difficult to decide, on two wounds being presented to notice, whether they are really the wounds of entrance and exit of one and the same projectile, or whether both are entrance wounds caused by two distinct projectiles. The two openings left by a single bullet might hold such a relative situation to each other, be placed so wide apart, and from other circumstances might seem to have so little connection one with the other, as to lead to the mistaken supposition that they have been caused by distinct projectiles; and careful observation has sometimes been necessary to prevent needless and hurtful search after bullets where none were lodged. A case occurred in the Crimea in which a bullet entered the scrotum, took a deep course, and made its exit from the back of the right thigh, without any

intermediate marks to indicate its true track. Here, from the want of apparent connection between the two openings, the conclusion was at first come to that two projectiles had entered, one at the thigh, the other at the scrotum, and that both had lodged. Search was made for them, of course without effect. Subsequent events showed both wounds had been produced by one and the same bullet. The length of the traverse of a bullet, and the consequent distance between the openings of entrance and exit; the fact of parts of the body being brought into unusual relations with each other, due to peculiarities of posture at the time of being hit; or of a bullet being subjected to a special deflection after entering the body—all these circumstances have been sources of similar errors in the early diagnosis of cases.

A similar difficulty is not likely to be encountered with regard to wounds inflicted by narrow armoured projectiles. Their penetrative energy is so great, that when once they have entered the body they will almost certainly continue their course onward and make their escape. The occurrence of two of these projectiles penetrating the body of a soldier at the same instant, and lodging, will be scarcely possible. If the exact direction of the fire can be ascertained as well as the position of the wounded man at the time he was struck, the course of the projectile through the limb or body of a man will almost certainly be made clear, for the path of a small-bore rifle bullet is commonly most direct. It will then be sufficiently evident that the two wounds under observation are the openings of entrance and exit of one and the same projectile.

Single bullets sometimes make more than two openings.—Surgeons were prepared in former days to find not unfrequently a greater number of openings, and more than one wounded track in the body, from a single bullet. This was liable to happen from several causes; and it might occur both from bullets that had remained entire, as well as from bullets that had been broken into two or more fragments.

Bullet remaining entire.—With a bullet remaining entire, the number of wounds may be increased by the projectile traversing two or more adjoining parts of the same person. A soldier of the 55th Regiment was wounded in the Crimea by a musket bullet, which entered between the glans penis and prepuce, ran beneath the skin without opening the erectile tissue, made exit at the root of the penis, passed into and through the scrotum, entered the thigh, and, finally, was cut out of the buttock. Five apertures were here made by the bullet, without counting the one for its extraction. I have seen an officer in whose case a bullet passed through the forearm, arm, and side, making six openings in its passage. Here the forearm was bent upon the arm, which, again, was in close contact with the trunk, the

wounded parts being thus in close relationship with each other. Similar occurrences will take place occasionally with all bullets—with the recent small-bore projectiles as with others. By an accidental discharge in May 1892 of a Lee-Metford rifle in camp at Aldershot, a soldier sitting on a bench was wounded in one of his thighs by the bullet, which, after passing through the limb, entered the other thigh, severed the femoral artery, and caused the man's death through hæmorrhage. Such multiple wounds in contiguous parts of neighbouring limbs form complications that often affect to an important extent the prognosis in practice.

The explanation of the occurrence is not always so easy when several openings have been made by a single bullet and where the wounded parts are remote from each other. A few years ago a farmer's wife was fatally shot by a revolver. When seen, lying in bed, by a surgeon, four bullet openings were discovered—two in the right thigh, and two across the abdomen. The two wounds of the thigh were manifestly openings of entrance and exit, the two abdominal wounds were similarly related one to the other, and these facts, with the absence of all apparent uniformity in their direction as the woman lay in a horizontal posture, made them seem to have been caused by two distinct projectiles. They had, however, been caused by a single bullet, and the explanation was, that at the time the woman was shot she was in such a position that the surfaces of the thigh and abdomen were in direct apposition and actual contact. After death, on flexing the thigh upon the abdomen, and placing the wounded parts in the relations just mentioned, the continuity of the course of the bullet along the thigh and through the abdomen was at once rendered obvious. A case has been recorded in which a bullet struck the right arm above the elbow, causing a comminuted fracture of the humerus, and then entered the left arm below the elbow, fracturing the upper part of the radius. The bullet had passed in front of the man's trunk without touching it.

The occurrence of multiple wounds in neighbouring limbs or parts of a wounded man is analogous to the circumstance of a single bullet passing through several individuals in succession. Examples of such occurrences have been frequent since the introduction of rifled weapons. In the instance of the soldier just now mentioned who was wounded in both thighs by a Lee-Metford bullet, the projectile had previously passed through one of the thighs of another man who was sitting on the same form by his side; and, not improbably, had a dozen men been sitting in the direction of the path of the bullet, it would have equally passed through them all, such was its force and penetrative energy. The rifle had been fired by a cordite cartridge at a distance of only about 30 feet from the wounded men, but the bullet had passed

through two wooden doors before reaching them. Many instances of such multiple wounds from single bullets may be expected to occur in future wars.

Multiple wounds—bullet divided.—Leaden bullets, both soft and hardened, were subject to division into two or more portions on colliding with objects presenting sufficient resistance, and when the division occurred from the missile being split against a bone within the body, each fragment was liable to cause a wound in a different direction. In this way the division of a bullet might not only increase the number of wounds of exit contiguous to the part first wounded, but might also cause fresh wounds of entrance in some other adjoining part. A bullet has been known to enter the thigh on one side, to become split into two parts against the femur, and, after escaping from the inner aspect of the same thigh in two directions, to enter the corresponding face of the opposite thigh at two points—one ball thus causing five orifices, two of them being wounds of exit, and three being wounds of entrance. Similar effects might result from the bullet being divided by having come into collision with some narrow ridge of a superficial bone, or by its having been cleft against the sharp edge of a broken bone after it had been fractured by the projectile. Many examples have occurred of the division of leaden bullets into two or more parts, from having struck against the spine of the tibia, the supra-orbital ridge, the clavicles, or against edges of fractured cranium, lower maxilla, and other bones. This occurrence has even taken place from a leaden bullet impinging against the narrow margin of the semi-cartilaginous vomer. When such an accident took place, the divided parts of the bullet naturally diverged and pursued their courses in different directions, so that the instances of single projectiles leading to several wounded tracks within the body, and either causing lodgment of foreign bodies in different situations, or making several wounds of exit, were by no means uncommon in former wars. Multiple wounds from such causes are obviously not likely to occur in future with the small-bore rifle projectiles, in which the leaden portion is encased in a resisting armour of steel, nickel, or other hard metal.

Multiple wounds—more than one wound of entrance.—In the instances just mentioned the original opening was a single one, whatever might be the number of wounded tracks or openings afterwards effected; but sometimes even more than one original wound of entrance occurred, owing to some accident happening to a projectile just before striking the body. Soldiers have been wounded in several places from bullets having been divided into two or more portions by striking against a neighbouring rock or wall, or against stones on the ground a few paces in front of them, the fragments rebounding or glancing off at various angles, and

still preserving force enough to penetrate the men with whom they afterwards came into collision. This, again, is a class of injuries which is not likely to be very often met with when the narrow armoured projectiles are in general use in war.

Less wounds than projectiles.—On the other hand, though happening more rarely, gunshot wounds in former days were occasionally less in number than the projectiles which had inflicted them. Several cases have come under my notice in past years among men invalided for the effects of gunshot wounds from whom two bullets had been extracted, though only one wound of entrance had been inflicted. The case of a gentleman who had been shot by a musket loaded with three bullets was recorded by John Hunter. In this instance there were only two orifices of entrance and two of exit, one ball having followed in the track of another; 'that there were three that went through him, was evident, for they afterwards made three holes in the wainscot behind him, but two were very near each other.' In the Pathological Museum at Netley there is a preparation of a femur taken from a soldier wounded in the Crimea, showing a fracture, the cure of which was prevented by the fact of two balls having entered by one wound, and the lodgment of the second at the seat of fracture having been undetected. With breech-loading rifles and special cartridges these accidents can hardly occur, but British soldiers have been exposed to be wounded by muzzle-loading arms for years, since the infantry of other European armies have had to encounter them in war. When muzzle-loading muskets were the weapons of our own troops, it frequently happened, under the excitement of action, that men, surrounded by the noise of musketry discharges, thought they had fired off their weapons when really they had not done so. Hence, double-loading was no uncommon occurrence, and the chance of more than one bullet entering by the same opening at short distances was proportionably greater. No doubt the same thing happens among the half-civilised and less perfectly equipped people in whose hands only muzzle-loading fire-arms are still found.

Even when bullets are fired from several distinct weapons, similar accidents may possibly occur. It is stated that in the case of a soldier who was shot for desertion and other crimes during the United States war of the rebellion, there were only eight entrance openings, although there was sufficient proof that ten bullets had passed through the prisoner's body. Four of the bullets must have passed through two of these openings.

CHAPTER II

CHARACTERISTIC FEATURES OF INJURIES FROM SUBSTANCES OF A GASEOUS FORM

Conditions which modify the characters of injuries from gases developed by explosion.—Gaseous substances, when they are urged forward with sudden violence, as occurs in explosions, act as veritable projectiles, and only differ from solid projectiles by their form of substance. The characters of bodily injuries produced by them, such as result from the ignition of gunpowder and the detonation of higher explosives, vary much more according to the manner in which the gas is directed against the body and the part of it which is struck, and these variations take place in a far more rapid ratio within limited distances, than do those of injuries produced by solid or liquid projectiles. This is manifestly due to the great rapidity with which such elastic substances quit the diminished volume under which they at first exist, and to the loss of elastic energy and propulsive force that takes place in proportion as the change is accomplished. The volume of gas resulting from the discharge of a blank cartridge from a weapon, the muzzle of which is placed in the mouth of a suicide, will tear the brain in pieces and separate all the bones of the cranium from its sutures; at the distance of a few yards the same discharge will inflict little more than a slight contusion; at a few yards farther off, nothing will be perceived but the impulse given to the surrounding air by it. The degree of severity of the injuries resulting from the gases produced by explosions, and the distances at which the injuries may be inflicted, greatly depend also upon the amount of gas evolved, or, in other words, the dimensions of the primary volume of gas, which constitutes the focus or centre of the sphere of destructive agency.

Wounds by gaseous projectiles.—The impulsive force of discharged gaseous substances is manifested in the production not merely of contusions, but also of the severest wounds when circumstances are suitable. Such wounds usually exhibit a markedly lacerated and contused character, and are very irregular in outline. If clothes are worn over the wounded part, they are liable to be torn asunder, or may be so caught by the gas as to be carried away altogether—'blown off.'

Wounds from concentrated volumes of gas.—If a rifle be charged with gunpowder, and fired close to the head of a person, but yet in such a position that the bullet passes away without striking it, the surface near to which the muzzle of the fire-arm was placed will probably be found bared and the scalp irregu-

larly lacerated. The scalp may be torn up in shreds several inches in length, in consequence of the force with which the gas propelled from the fire-arm has passed on between the bone and its covering; the latter being stretched to its extreme limit, and then rent asunder. Corresponding results will ensue whatever part of the body may be exposed to a concentrated gaseous discharge directed against it in a similar way. The wounded surface, if the explosion has occurred very near to it, may be reached by the flame attending the ignition of the powder, and grains of the powder that have escaped the fire may be driven forcibly forward, so that the injury from the gas is complicated by a certain amount of scorching as well as of tattooing from lodged particles. When the volume of gas is greatly increased, as when a field-gun is fired with blank cartridge, if a limb of a person be exposed to the stroke of the emitted gas, it will be torn from the body, or if the whole body be exposed to the discharge shortly after its emission from the muzzle of the piece, it will be torn asunder into fragments, and its portions driven to long distances through the air. Many terrible examples of this fact were afforded in 'blowing away' rebel Sepoys from guns at the time of the great Mutiny in India.

Injuries from gas of less tension.—With a similarly large volume of gas, if the person exposed to its impact be at a moderate distance off from the point of discharge, the injuries produced will probably consist of general concussion with a certain amount of compression and contusion, but without any open wound. There will frequently be the evidences of local contusion and of muscular strains in the parts most exposed to the blow, but external signs of injury are often absent.

Injuries from the gas of exploded missiles.—Examples of injuries of the severest nature occur from time to time in warfare in consequence of the bursting of a shell close to a soldier, when none of the fragments have come into collision with the injured man's body. Soldiers soon learn in warfare, almost instinctively, in case of a live shell falling near them with its fuze burning, and of there being no time for escape by flight, nor means of getting cover, that their chief chance of avoiding destruction consists in throwing themselves flat on the ground. Under such circumstances, if the shell happen to burst near the head of one of the prostrate men, the brain and medulla oblongata will probably exhibit signs of serious injury, though no visible wound is inflicted; or if it burst so that the force of the explosion is urged against the chest or abdomen, the violent agitation of some of the viscera contained in the cavities of these regions will almost invariably lead to grave and not unfrequently fatal results. Mr. Erichsen has mentioned a case in which a pistol charged with powder alone was fired against the chest of a man, when death,

from concussion of the heart, was the consequence.[17] In July 1867, at Jhansi, in India, a stout young soldier discharged a large pistol against the left side of his chest. There was a wound about four inches below and behind the nipple, leaving a rib bare. He went on favourably under hospital treatment till towards the evening of the second day after the injury, when collapse supervened, and he died the same night. At the post-mortem inspection a very large quantity of blood was found in the abdomen. It had escaped from an extensive rupture of the spleen. No foreign body had entered either the abdomen or chest, and the rupture was manifestly due to the blow of the exploded powder in the neighbourhood of the rent organ.[18]

The same timely warning, enabling men standing near to throw themselves upon the ground before the shell bursts, does not occur with a percussion as it does with a fuze shell. On such shells bursting, the men close by who have escaped from being struck by their fragments have often suffered from severe contusions about the legs. They have not hitherto, as a rule, been placed in the same danger as regards life from this source as men lying on the ground, for the force of the exploded gunpowder has become lessened in intensity before it has reached the vital parts of the body. But such escapes can hardly occur when, instead of gunpowder, some of the modern high explosives are used for bursting charges.

The contusion from the gas seems to produce in some of the cases just mentioned a vibratory disturbance of the internal organs adjoining the part of the body on which the impact of the projected gas is directly received. The fact of the force of the vibrations varying in intensity will cause proportionate differences in the amount of the resulting lesions in the organs concerned. In slight cases the effects will pass off comparatively quickly; in severe cases, in which probably the concussion has led to some lesions of the finer tissues, serious impairment of their functions may last for years. Not even a bruise of the surface may in some instances be perceived; perhaps no lesion internally would be apparent were the opportunity of observation presented. If the force of the impact be directed against the head or back of the neck, any of the usual consequences of cerebral or spinal lesion may be presented to notice.

Injuries to mental faculties from gaseous projectiles.—Mental faculties are apt to be more or less weakened by the impact of gaseous projectiles in concentrated volume, and one very common feature presented in all such cases is not merely a diminution in power of some of the intellectual faculties, but an irresolution of purpose and a degree of timidity which may be altogether foreign to the previous characters of the individuals concerned. It is very important to bear in mind in such cases that these alterations of character are due to physical changes, the result of the injuries to

which the patients have been subjected. Medical officers, by duly weighing these circumstances, may often be the means not merely of saving officers and soldiers from obloquy which they do not deserve, but also of helping them towards obtaining the compensation to which they are justly entitled, not alone for the bodily harm which they have sustained, but also for the moral deterioration which has been inflicted upon them entirely by their duty in the public service, and not in consequence of any private fault. These cases are analogous in their nature to cases of concussion which occasionally result from railway injuries when no external wounds or damage are presented, and the patients are as much entitled to compensation for them, when their nature and origin are properly established, as they would be for other injuries.

Injuries to the organs of hearing and sight.—Two of the organs of special sense, the ear and the eye, are often materially injured by the effects of explosions, but more especially the former, as might be anticipated from the nature of its function. Injuries to the organ of hearing from the concussion resulting from discharges of fire-arms frequently come under the notice of military surgeons. The violence with which the column of gas is forced against the membrana tympani is liable to rupture it, and the excessive concussion of the auditory nerve is often sufficient to paralyse for a time, or even to permanently deteriorate its function. The accident to the Duke of Wellington, who had the tympana of both ears ruptured by the unexpected discharge of a howitzer opposite to which he was suddenly brought while mounting a hill, has been already alluded to. Injudicious treatment in the Duke's case led to complete deafness on one side, and permanent diminution of auditory power on the other side. The severity of the injury depends not only upon the intensity of the stroke, and upon the relative position of the soldier to the undulations of emitted gas, or of the air set in motion by it, but seems also to be greatly modified according as the sufferer's ear is prepared or not for receiving the blow. Some of the effects of this source of concussion were well exemplified in the instance of my friend Lieutenant-Colonel (now General) H. Brackenbury, C.B., who was struck during the siege of Paris in 1871 by a column of gas emitted from the exploded charge of a shell. I cannot do better than use Colonel Brackenbury's own account of the injury written in a letter to me not long after its occurrence. 'On Tuesday, April the 25th, I was in No. 1 Battery on the plateau of Chatillon, under a heavy fire from the fort of Vanves. Two guns were already dismounted. The embrasures opposite the two remaining guns were blinded by gabions. I was looking out with my field-glass between the gabion and cheek of one of these embrasures, when warning was given of a shell coming. I stepped away, and placed my back against the merlon, close beside the embrasure. A heavy shell came in

through the embrasure, knocking the gabion to pieces, and burst on the gun-wheel about three feet from, and to the front of my right side, dismounting the gun. I felt such severe pain in my right ear that I thought I was wounded, and said, "*Ça m'a cassé l'oreille.*" But I was not hit. The right side of my face swelled up, and I was deaf on that side for a considerable time. The muscles of the neck also gave me some pain. Ten days afterwards the pain in my ear suddenly grew sharper, and an abscess burst in it, followed four days later by a second. I then got rapidly better, and am now well; though sometimes both ears seem dull, and ache a little.'

When the face of a person is turned towards the focus of an explosion, and he is standing near enough to be violently concussed by the movement of the impelled gas and air, his power of vision is not unlikely to be injured. The mischief done for the most part is only of a temporary character, but occasionally sight is permanently destroyed. In many of these cases the injury to the eyes is of a mixed nature, the lesion not being entirely produced by the concussion, but being also partly due to the scorching effects of the flash of flame accompanying the explosion, or to the impact or penetration of solid bodies, such as grains of gunpowder, sand, and gravel, or other substances. But in other cases the loss of vision is due solely to the effects of the contusion and concussion resulting from the impact of the volume of gas. Thus in the history of the Crimean war it is specially mentioned in one instance, in which blindness followed exposure to a magazine explosion, that the blindness was solely due to the direct force of the concussion. In this case the eyeballs remained full, and retained their natural rotundity, and the only alteration noticed was a bluish-white opacity of the whole of each cornea, which took place within a few hours of the receipt of the injury. This was not due to the flame having reached the eye, but to part of the aqueous humour having been forced between the layers of the cornea. The amount of inflammatory action which followed was very slight, but vision was completely and permanently destroyed, probably by concussion of the optic nerves.[19] Mr. (now Sir William) MacCormac, in his 'Notes of an Ambulance Surgeon,' refers to a case that came under his notice at Sedan, of 'temporary loss of vision from a shell explosion close by, which caused no further injury.'[20] Even the explosion of the comparatively small quantity of powder which is contained in an ordinary cartridge may produce the same serious consequences, if favourably directed for inflicting a sudden forcible compression of the organs of vision. A soldier of the 68th Regiment had the sight of both eyes destroyed in the trenches before Sebastopol by the concussion resulting from the explosion of an enemy's musket close to his face; the ball passed without injuring him.[21]

Effects of magazine explosions.—But the most terrible effects of explosions are witnessed in instances of accidental ignition of large stores of gunpowder contained in magazines, whether in those collected for the service of the batteries in siege operations, or in the still larger magazines of reserve supplies placed in rear of the trenches, or stored in arsenals. Catastrophes of this kind are not unfrequent occurrences in connection with military operations. Several instances of them occurred during the Crimean campaign. The most extensive which took place, and probably one of the most formidable that has ever occurred in warfare, was the explosion of the magazines of gunpowder and munitions of war in the French siege park and the adjoining English siege train enclosure on the 15th of November 1855. According to Dr. Chenu,[22] the magazines which exploded in the French park contained 50,000 kilogrammes of powder, 4000 large projectiles and rockets, and 600,000 small-arm cartridges; while the losses among the troops were 4 officers killed and 11 wounded; 16 sub-officers and soldiers killed, 13 disappeared, and 103 wounded.[23] A Divisional Field Hospital near the scene of the explosion was destroyed, and six medical officers were wounded. On the English side, chiefly in the regiments of the Light Division and in the Right Siege Train, 1 officer and 20 non-commissioned officers and men were killed, while 4 officers and 115 non-commissioned officers and men were wounded.[24] The extent to which projectiles were scattered by the explosion is shown by the fact that these casualties occurred in the camps of no less than fourteen regiments. In some instances the bodies of men were so torn asunder and mutilated, and the detached parts scattered to such distances in different directions, by the force of the explosion, that collocation of the parts belonging to each other was impossible. Dr. Chenu accounts for the French 'disappeared' by suggesting that some of the victims of the explosion were buried under the ruins, and not found again. As the flame of the explosion set fire to the adjoining huts and tents, the remains of some of the missing were probably lost in this fire.

The numbers above given comprised those who were actually killed and wounded by the force of the explosion itself, or by the various solid substances which were projected by it in all directions. Every description of wound and injury was produced by the numerous and varied agencies derived from the explosion. Many men were wounded by the fragments of exploded shells. But, in addition to the casualties enumerated in those statistics, there were large numbers who, though not struck by any solid projectile, nor visibly wounded by the impulsive force of the explosion, were yet more or less seriously contused and injured by it. Some suffered from rupture of superficial blood-vessels of the air-pas-

sages and lungs, others from temporary disturbance of hearing. Especially prevalent, however, was shock to the general nervous system, and this was manifestly not the result of panic, but was largely due to actual physical concussion and contusion.

At the time of the explosion, I was sitting alone in a small stone hut, constructed out of such materials as were at hand, on the extreme right flank of the First Brigade of the Light Division, about five hundred yards in a direct line from the Parc de Siège, where the explosion occurred. A shower of projectiles fell about the hut, and among others, a shell of large size burst immediately over the roof, as was afterwards proved by its fragments being found close to the walls on the two opposite sides of the hut. The roof of the hut, which was made roughly of wood covered by hides, was twisted partly round, and a small skylight, by which the interior was lighted, and which was just above the table at which I was then writing, was blown in. I myself was knocked off the stool on which I was sitting, down to the floor, without, however, being touched by any solid substance, and for the instant was deprived of consciousness. I judged that I could only have been a few moments in this condition, for, on getting to the door, which I seemed to have done with the intention of escaping, but at the same time almost automatically, numerous projectiles were still bursting in the air and on the ground, and drove me back. The earliest impression which I found on my mind on consciousness returning was that a mine had been sprung by the Russians beneath us—a notion momentarily entertained by others, as I afterwards learned—and no doubt this feeling got its origin in the trembling of the ground which accompanied the explosion. Any one who has experienced the agitation of frame which is produced by the wave movement of the floor of a building, or of the ground itself, during the progress of a severe earthquake, as I have done, will readily comprehend the influence which would be exerted by such a movement of the ground as took place on this occasion, from the tremendous concussion to which it had been subjected. This movement was not noted by myself, but was by many others; the fall, and the temporary stupor to which I was subjected, probably deprived me of the power of observing it. When, shortly afterwards, I left my hut to make my way to the hospital, one of the first men I met was a strong, powerfully framed artilleryman belonging to the Right Siege Train, who had been rendered suddenly fatuous by the explosion. He was not paralysed, for he was being helped along walking, though with a tottering and unsteady gait, and the peculiar vacant expression of idiotcy. I stopped the two men who were leading him, and hurriedly examined him. There were no marks of injury upon the poor fellow's body; but his intellectual faculties seemed to have been completely obliterated by the shock to which

he had been subjected, and the impression on my mind was that they had probably gone past recovery.

On afterwards considering the event as regarded myself, it appeared to me that the shock from the explosion was too instantaneous for fear to have had any part in the effects it produced. The intensity of mental surprise at suddenly hearing so immense a volume of sound, and at feeling simultaneously the shock to the whole system, both happening at a moment when mind and body were totally unprepared for the occurrence, no doubt had an important influence; but what the amount of this influence was, as compared with the amount due to physical agitation of the frame from the aërial impulse, it is difficult to decide. I am inclined to attribute the greater part of the effects—the temporary paralysed condition of body, and the accompanying stupor of mind—to the disturbance of the brain and nerve-centres by the actual molecular agitation produced by the violent impulse of the air; and to regard the time occupied in the return of perception and of voluntary power as indicative of the time taken by the shaken structures in recovering their balance, which had been so suddenly interfered with. And this seems to be borne out by the fact that the nearer to the centre of impulse, and therefore the more violent the force of percussion from the detonation, the greater in amount and the more persistent the disturbance usually is, and the slower the recovery.

The shock from explosions modified by habit.—One peculiarity connected with the shock and other symptoms produced by explosions is the extent to which these effects are modified by the influence of habit. Artillerymen are affected in various ways when they are first trained to the use of heavy guns, especially when they are fired on ship-board, in casemates, and under other circumstances in which there is much reverberation from the gases evolved not having means of free escape into the surrounding atmosphere. But these effects gradually pass away with practice and custom if men are in a vigorous state of health.

I was at one time in a station in the West Indies where the morning and evening gun, the report of which was audible at many miles' distance, was fired close below the mess-room. Persons and articles of furniture in the apartment were shaken every time the discharge took place. Yet, after being accustomed to the occurrence, the firing of the gun often passed so unnoticed that the question was not unfrequently asked among us whether the gun had, or had not, been fired. The vibratory agitation of the air, and the sound of the heaviest bombardments of Sebastopol, made less impression upon those who had become familiar with the effects of the constant cannonading from long residence close to the siege works, than the cessation of it did after the place fell. For a few days after this event the great change to continuous

silence, and to comparative stillness of the atmosphere, was as painful to those who had been long accustomed to the siege operations as agitation of the air and the roar of a heavy bombardment had been to new-comers. The influence of custom in modifying the disturbance to particular organs, and the effects of the general shock to the body, produced by the concussion of the air resulting from explosions, is one of not the least curious circumstances connected with this subject. When men are depressed in general health and debilitated, or are suffering locally from the effects of injury or disease, the favourable effects of habit in the respects mentioned are not always so manifest; on the contrary, increased irritation is sometimes excited by the repeated vibrations and noise, and it then becomes necessary for the patient's recovery that he should be removed from the sphere of agitation to which the repeated discharges of cannon subject him.

Some of the particular local effects of explosions on special organs can be best studied when injuries of the regions to which the organs belong are under consideration. The burns with which such explosions are often accompanied will also be considered in another part of this work.

Injuries from fougasses and torpedoes.—Injuries resulting from the action of exploded gases on the feet, legs, and lower parts of the bodies of soldiers are met with from other causes besides the explosion of shells. They are especially liable to be met with on the occasion of an assault when contrivances of various kinds are employed to prevent the approach of assailants. A soldier by whose weight in walking a fougasse is exploded, can scarcely escape from the effects of the rush of the pent-up gas, even if he happen not to be struck by the stones, fragments, and other miscellaneous missiles projected by the explosion. The effects are shown in terribly severe injuries. Sometimes grave mischief occurs, such as comminuted fractures of the bones of the foot and leg, with severe contusion of internal tissues, without visible lesion of the superjacent integuments; sometimes extensive laceration of soft parts, with tearing asunder of the tarsal bones, and fractures higher up the limbs result; sometimes parts of the feet and legs are blown away altogether, with great injury to the structures for some distance above the site of separation. These injuries, as might be expected, are complicated in numerous instances with burns from the flame emitted at the moment of explosion, as well as with wounds from the various missiles projected by such machines; but even when unaccompanied by these complications, the mischief done by the force of the exploded gas upon any one who happens to be within the immediate sphere of its influence is generally so great as to lead to the necessity of amputation of portions of one or both lower extremities. Exceptions do, however, occur. Two men of the

97th Regiment trod upon fougasses in front of the Redan, after the place had fallen, and had only their trousers torn off, with slight scorching of their limbs by the flame of the explosion; they escaped without any deep lesion. A staff officer in the Crimea, the tread of whose horse in galloping caused one of these sunk mines to explode, had a narrow escape, for the hair of his horse's tail was singed, while one of the men behind him was killed and several others injured. In the instances of men who have been killed on the spot by fougasse or torpedo explosions, extensive injury to some of the viscera of the trunk by solid projectiles has generally occurred.

High explosives.—Accidental explosions on a large scale of several of the new explosives, or so-called smokeless powders, described in a previous chapter, have occurred on various occasions, and have entailed the loss of many lives and the infliction of numerous bodily injuries. The effects of the explosion of the chemical substances alluded to have been studied and described by surgeons both on the Continent and in England. They have been on the whole very similar to those produced by the explosion of gunpowder, only more intense in character, having regard to the quantities of the respective substances exploded. That such would be the result might be anticipated from their known extreme rapidity of expansion and proportionately increased violence of impulsion. Within the sphere of sudden expansion, the nearer to the centre of the gaseous evolution and movement that resistance is offered, the greater the destruction effected, so that persons who happen to be close to the explosive source, if the explosion be considerable, may be literally torn to pieces, their limbs and parts of their bodies being separated from their natural connections, and carried away in different directions. At a somewhat greater distance from the focus of explosion, it may happen that only the clothes worn by a person exposed to the sudden impulse are torn from the body, while the surfaces exposed to the air are subjected to contusion, more or less deep and extensive, with injury to internal organs by concussion and compression. The same violent and sudden impulse that is the source of injury to all bystanders exposed to the effects of the explosion, acts on all the solid substances, small and large, in the neighbourhood, and they often become, according to their respective positions, forms, and other qualities, so many additional instruments of injury to those with whom they happen to be brought into collision. The injuries inflicted in such catastrophes do not include the burns which usually accompany explosions by gunpowder and other sensitive inflammable substances, as the emission of flame is not one of the accompaniments of the detonation of such high explosives; but the gaseous vapours evolved by the explosion of dynamite are especially irritating to the air-passages of all persons exposed to their influence.

CHAPTER III

CHARACTERISTIC FEATURES OF TRACKS LEFT BY BULLETS IN DIFFERENT PARTS OF THE BODY

Shape and dimensions of a bullet track.—The shapes and dimensions of small-arm bullet tracks have become materially altered in proportion as the sizes of the bullets have been reduced and their velocities increased, and now, since the latest small-bore projectiles have been introduced, the wound tracks resulting from them retain hardly any of the features which at one time distinguished such lesions. When spherical bullets were in use, the tracks left by them, whatever might be the relative positions of the entrance and exit openings, were always characterised by their irregularity and by uncertainty regarding the lesions they had caused in their passage. They often pursued the most unexpected directions. Such deviations were due to their mode of rotation, their obtuse form, and the effective resistance often opposed to their onward movement by some of the structures which they encountered on their way.

When cylindro-conoidal bullets began to be employed, the tracks left by them in wounded parts were generally more straight and direct, owing to their elongated shape and manner of rotation, but were frequently not so direct and even as was anticipated. When a digital examination was made of the track left by one of these bullets, even when it had passed in a direct line through a fleshy part of the body or one of the extremities, it was often a matter of surprise how irregular it was in its dimensions and shape. Instead of a regular conduit or canal of even calibre, a hollow wound was felt, constricted at one part, free and expanded at another, and deviating here and there in various directions from a straight rectilineal path. The finger found substances opposing its direct passage onwards, which it had to displace in order to continue its further progress, and these substances presented to the touch different conditions and degrees of resistance.

It was sufficiently easy, when the velocities of translation and rotation were considerably less than they are at present, on calling to mind the varied anatomical structures which enter into the composition of a given part of the body; the different physical qualities of these structures as regards texture, elasticity, form, and power of resistance; their mutual relations, particularly in regard to fixity or looseness of position, and their modes of connection one with another, to understand why such irregularities should be found in the tracks left by bullets. The fact was of course recognised that the speed with which the missile

traversed the wounded part materially influenced the extent to which the special qualities of the structures traversed could be exerted. It was accepted as a general rule, that when a bullet maintains its direct course, the higher the rate of speed the more direct is the track, and the more complete is the destruction of all the parts opposed to its passage, whatever their nature.

While considering the principal causes of the absence of uniformity in the tracks of projectiles through parts of the body, one other circumstance which helps to produce such irregularities should be named. Whatever may be the position of a limb, or inclination of a part of the body, at the instant it is traversed by a missile, a change of attitude of the wounded man at once changes the relative positions of the various structures composing the parts concerned in the injury. The change which takes place in the regularity of the internal wound from this simple cause is often much greater than might be anticipated.

The characters of all gunshot wounds become materially altered in respect to shape, size, and amount of laceration, if the projectile has been caused to traverse the tissues in any other than the normal direction on its long axis ; as when an elongated bullet has been caused to pass through them while rotating on one of its short axes, or has ricochetted from a stone, gravel, or other hard substance on the ground. Some of the effects of such accidental alterations in the manner of flight of bullets upon wounds have been already noticed when the subject of the dimensions of bullets was under consideration in a preceding section of this work.

It is useful still to be acquainted with the general characteristics of the openings made in the several anatomical structures through which one of the older forms of cylindro-conoidal bullets had effected a passage. The same effects may be observed, though more or less modified according to circumstances, when some of the projectiles in use at the present day inflict wounds.

Bullet openings in fascia.—When the structures composing a part of the body through which a bullet has passed are separately examined, much diversity will be observable in the shapes and sizes of the openings made in them by the projectile. When an Enfield or Martini-Henry bullet has inflicted a flesh wound through a part of one of the extremities—the thigh for example—while maintaining its ordinary mode of flight, and retaining an average rate of speed, the first part of the track will usually feel constricted as compared with the parts beyond. This may sometimes be due to contraction of the opening through the skin and superficial fascia, but is more generally the result of the peculiar slit-like opening through the aponeurotic fascia beneath. The opening through this fascia is usually very little due to actual removal of its substance, but is principally brought about by division of some, and separation with temporary displacement of

others, of its principal parallel fibres. The tendinous fibres, thus displaced, being afterwards put on the stretch by muscular action, or by movement of parts beyond the seat of injury, or by simple alteration in position of the part of the body concerned, are then caused to approach each other, and thus to narrow and contract the opening. The bullet probably pushes before it the resisting fascia upon the soft tissues below, until the connective tissue uniting the principal longitudinal fibres gives way, and allows the greater part of them in front of the bullet to yield to each side, very few of the longitudinal fibres being actually divided; while the crossing fibres of a weaker description are either, as mostly happens, torn asunder, or are similarly separated by the destruction of their connections. The bullet opening is thus converted either into a kind of torn or fringed slit, the direction of which corresponds with the direction of the principal and strongest fibres of the fascia at the seat of injury, or into a more or less rectangular aperture bounded on each side by the crossing tendinous fibres which have been left entire, like the square opening which is seen in a piece of canvas through which a round bullet has been fired. An opening closely resembling the mere slit first mentioned has been observed in the fibrous structure constituting the anterior common ligament of the vertebral column after the passage of a bullet. M. Legouest has recorded that he saw a case in which a projectile of small volume had penetrated the body of a vertebra from the front. The vertical fibres of the covering of the bone, after being traversed by the projectile, closed toward each other, so as to conceal the penetration and the fact of its presence in the body of the bone.[25] Occasionally, however, a cylindro-conoidal bullet, probably when it was armed with a very high rate of velocity, and sufficient time was not allowed for the fibres to move aside out of the way of the projectile, left an opening which was no longer of the nature of a slit, but closely corresponded with the shape of the projectile. This will probably be the general character of the openings left in fascial structures after penetration by small-bore projectiles, owing to their immense penetrative power at all ordinary distances.

Bullet openings in deep aponeuroses.—The deep aponeuroses and intermuscular ligamentous tissues, the sheaths of many muscles, are affected by the passage of projectiles in a similar way to the fascia investing the superficial parts of the body. The fibres of the sheath of a muscle may be so acted upon by a cylindro-conoidal bullet passing through it at a medium rate of speed as to be simply torn asunder and separated from each other, and thus, on being drawn together again by some cause, may cover up the hole which has been made in the muscular tissue. But if the sheath of the muscle be dense on the opposite aspects of a thick muscle, as happens in the rectus, and in some of the muscles of

the extremities, the part of the sheath through which the bullet first penetrated is acted upon differently from that which is last perforated. The front of the sheath pressed towards the muscle retains its connection with it around the track of the bullet, a few of the principal fibres being torn across and their ends curled up, but not extending beyond the margin of the opening in the muscle; while on its posterior aspect, where it is pressed from the muscle, the sheath is more or less torn away from its connections, and the fibres of the sheath extensively separated from each other. The front opening therefore often appears more circular and limited, the posterior more elongated. The same difference is met with in the openings of the aponeurotic fascia on the two opposite sides of a perforated limb. At the opening of entrance the connections of the fascia with the structures which it covers are but little disturbed, and the opening is more contracted in size than the opening of exit through the fascia on the other side. The opening of exit is rendered more free by being forced away from its connections with the muscles to which it was previously attached, and by its fibres being more extensively torn asunder. On holding to the light a portion of fascia through which one of the cylindro-conoidal bullets used with the Enfield or Martini-Henry rifles had made its exit—the fascia-lata of the thigh for example—the separation of the longitudinal fibres might be seen to extend considerably beyond the actual opening, though they were still held loosely together by crossing fibres of a weaker description and by connective tissue.

Long tendons, nerves, and blood-vessels in bullet tracks.—Tendons have hitherto exhibited a remarkable immunity from division by bullets. They have frequently escaped division, though subsequently they were felt to be in the course which the bullet had taken. They must in many such cases have been pushed aside, and then have returned to their previous position, thus interfering with the continuity of the direct track so far as observation of the wound by a finger was concerned. In like manner other long and mobile structures, though not possessing equal strength and tenacity, as nerves and blood-vessels, used frequently to escape without being divided. When a bullet strikes direct upon and passes through a broad tendon like the ligamentum patellæ, the opening left is well defined, but, owing to the elasticity of the tendinous fibres, appears to be smaller in diameter than the diameter of the bullet by which it was caused. On the other hand, the divided ends of a narrow tendon which has happened to be partially or entirely cut across under like circumstances, usually present surfaces which are much torn and very irregular, perhaps from having been divided by the bullet against a bone, or from having been greatly stretched before giving way to the opposing force. Experiments with the new

narrow bullets seem to prove that long tendons, however tough, are not likely to be pushed aside by them so long as they retain their high rates of velocity, but that they will in most instances be either perforated or divided by them.

Bullet openings in adipose tissue and muscles.—The common cellular adipose tissue, offering little resistance against perforation, presents an opening corresponding with the size of the bullet, or, if any alteration in size occurs, the change depends probably more upon the qualities and movements of adjoining structures than upon any action of the cellular tissue itself.

The substance of the muscular structures also is endowed with but little power of resistance against the forcible passage of a bullet. The part directly opposed to the projectile is compressed, disintegrated, and carried away in front of it, or dispersed in the surrounding tissue. Sometimes a large hole irregular in shape and size, sometimes a canal-like opening, is left through its substance. The condition of the track left by the bullet is probably modified to a certain extent by the condition the muscles happened to be in at the time of the passage of the projectile. A muscle in an active state of contraction, or passively stretched, will present a more firm and resisting front to the projectile than a muscle in a condition of relaxation. There will be more complete destruction and removal of substance, therefore, in the two former states of the muscle than in the latter. In the relaxed condition of the muscle there will be more stretching and tearing, and more return of its fibres upon the opening through which the projectile had passed. The track will be again modified in its characters when the state in which the muscle happened to be at the time of perforation is afterwards changed; when the stretched muscle resumes its ordinary state of repose, and the contracted muscle returns to a state of relaxation.

The large gaps occasionally met with in muscles.—The reasons already given do not, however, suffice to explain the spacious gaps which were occasionally met with in muscular tissues wounded by the elongated bullets recently in use when these projectiles had appeared to preserve a direct line of flight. The probable explanation in these instances is that the wounds were inflicted by the projectiles very early in their course—when they had lost scarcely any of the destructive energy originally impressed upon them. How enormous this amount of energy was in the bullets in recent use, even at long distances from the rifle, may be seen in the table showing the *vis viva* retained by the Martini-Henry projectile at different points of its course. The active force of the most recent small-bore projectiles, as shown elsewhere, is considerably greater. Under such circumstances, just as when a bone is broken, its fragments become converted into so many projectiles, so even the fluid blood and the disintegrated particles of

muscular tissue may be propelled with force enough to act in the capacity of secondary missiles, and increase the area of laceration. When an animal near a wall is shot through the body, or through the fleshy part of a limb, by a rifle bullet at a very high rate of speed, one effect is that the wall is more or less widely splashed with a quantity of blood. This blood has been forced by the bullet through the wound of exit. The blood has received part of the momentum of the bullet, and has itself passed onwards with a large amount of force. If closely examined, there will be found also upon the wall and on the ground between it and the animal a quantity of particles of muscular pulp. The disintegrated muscle, like the blood, has acquired a certain velocity of movement from the projectile which has mashed it up, and itself has been turned into a projectile; as much as if tallow or any other soft material were fired direct from a fire-arm, or as water struck by a shot possessing great momentum is driven with considerable initial force from the site of impact. It seems only in this way that the large gaps can be explained which are occasionally effected in the muscles by elongated projectiles of small diameters when they have preserved their direct line of flight and only soft tissues have been traversed by them.

Effects on bullet tracks of collision with bone.—If the shaft of a bone happen to be struck, the whole track of a bullet becomes greatly changed. If the bone be unbroken, though grazed or slightly grooved, the line of the track is simply turned in another direction, unless the mode of rotation of the bullet be altered, when other changes, elsewhere explained, take place. If the bone be pierced through, but not splintered, no material change in the direction of the track is noticeable or occurs. If the bone be comminuted, the track is altered in size, shape, and condition, according to the situation of the bone broken and to the nature and circumstances of the fracture, especially in regard to the number and shapes of the fragments, and the extent to which they have been driven into the adjoining structures. The number and shapes of the fragments, and the distances to which they are driven, will mainly depend upon the amount of active force retained by the bullet that inflicts the injury; the size, power of resistance, and brittleness of the bone struck; and, to some extent, the qualities of the tissues by which it is surrounded, whether they be aponeurotic or thickly muscular. If a rifle bullet of toughened lead, such as the Martini-Henry, when armed with its full force, strike a hard and powerful long bone, like the femur for example, near the middle of its shaft, it is broken up into fragments, often too numerous to be counted, of various shapes and dimensions. A large proportion of these fragments are driven violently in various directions, and are thus converted into secondary missiles. They give rise to much the same kind

of action among the surrounding soft tissues as an explosive bullet would exert. A large cavity is formed inside the limb, which, when it is fully laid open and the effused blood sponged away, offers to view a mass of lacerated muscle intimately mixed with sharp-pointed and jagged-edged splinters of bone. The splinters have been driven forward, thrust aside, and turned round; in short, impelled with great force in all directions. They cannot for the most part be readily separated from the tissues into which they have penetrated. The muscles on the near side, that is, toward the wound of entrance, are torn up as well as those on the distant side of the limb, though the latter will be most extensively disorganised. Probably the skin on the opposite side of the limb to that at which the projectile entered will exhibit one or more long rents through which muscle and pieces of bone have protruded. The bullet, if a leaden one, will probably be itself broken, and either it or portions of it may escape through one or other of these rents or by separate openings. If it be one of the small-bore compound bullets, the bone may be equally smashed, and terrific damage done around the seat of fracture. The bullet in some instances will pursue its course with little alteration in shape, and escape; in others, the cover may be more or less separated from the core, or even broken up in some kinds of mantled bullets, causing a wide and greatly lacerated track up to the opening or openings of exit. With all this extensive destruction within the limb, the external aspect of the wound through which the bullet first entered may exhibit nothing more to view than a small opening into which the top of the little finger can scarcely enter; thus presenting a remarkable contrast with the internal condition of the track, and the widely-spread and irreparable mischief which the bullet has directly and indirectly done to the structures which have been injured by it in its passage.

As the velocity of the projectile becomes lessened, so the conditions of the fracture of bone, when fracture is effected, as well as the extent of the surrounding area of mischief, become altered. If the velocity be greatly reduced, so that the missile becomes a spent one by the time it reaches the bone, though no fracture take place, the bone may be found to be contused, or there may be more or less abrasion of the periosteum. Such lesions more frequently occur when the projectile by which the wound has been inflicted is a small fragment of shell, a slug, or some other irregularly shaped and angular missile of comparatively small dimensions.

Lengths of bullet tracks.—The prevailing lengths as well as the directions of bullet tracks may often be traced to the nature of the military operations in which the troops are engaged. In the open field, when the opposing forces are moving on nearly level ground, the majority of the wounds presented to surgeons

have tracks which are more or less transverse in direction, through or across the body, limbs, &c., the openings of entrance and exit being nearly on the same level. In fights against an enemy occupying the rocky sides of hills, as in mountain warfare; in attacks against lofty forts, against enemies occupying the roofs or upper windows of houses—in short, on all occasions in which bullets are fired downwards—'plunging fire'—against troops attacking from lower positions, very long tracks, more or less deep, through the superficial parts of the body and limbs are brought under the care of surgeons. On the other hand, the tracks of the wounds received in such conflicts by those who are engaged in the more lofty positions usually have more of an upward slanting direction, and principally occupy the upper parts of the body. The entrance openings are above, the exit openings below, in those on the lower ground; while the positions of these openings are reversed in those who are wounded while acting on the higher levels.

Removal of substance in bullet tracks.—It may be observed that the description which has been given of the internal condition of a bullet wound does not agree with the statement, sometimes made, that there is no removal of substance in the track of a bullet through the soft tissues of the body—that a gunshot wound, when produced by a small projectile, is merely a separation of adjoining parts, though, from the manner in which this separation is caused, the surfaces previously united with each other are so contused as to be deprived of vitality to a greater or less extent according to circumstances. Those who adopt this view have probably accepted it in the first place from Mr. Guthrie's remarks on these injuries. That distinguished army surgeon, in explaining the nature of simple gunshot wounds of muscular parts, writes: 'The ball has forcibly torn its way through the soft parts, and by the quickness with which this has been effected, they are deprived in part of their sensibility and life; but there is no absolute loss of substance, there is none driven out. . . . The track of the ball is then partially filled with matter deprived of life, and which must be discharged before the part can be restored to its natural state; but this dead matter retains its attachment to the surrounding substances, and must be removed by the process called sloughing.'[26] That there is, however, as a general rule, an absolute separation and loss of substance in the skin, and also in the deeper tissues, when a bullet, whether spherical or conoidal, and whether of large or small diameter, is projected through these structures with a very high rate of velocity, repeated observations and experiments sufficiently prove.

The passage left by a bullet which has passed through the reticulated tissue at the extremity of a bone affords a good typical illustration of what takes place when other organised structures, such as muscle and areolar tissue, are opposed to the action of a

projectile travelling with great velocity. In the cancellated bone there is no change in appearance or condition from elasticity, traction, or swelling, and no circumstances exist by which the results can be modified; the parts remain in the same state in which they were placed by the bullet forcing its way through them, and its action upon them can therefore be studied without risk of error.

Take a direct wound of the head of the tibia made by a spherical bullet for example. If such a wound be examined after all blood has been washed away, a tunnel of the same width as the bullet remains. The space through which the bullet has passed is quite void. The minute interwoven fibres of bone which bounded the cells, the membrane which lined them, the blood-vessels which circulated among them, and, in short, all that occupied the path of the bullet, have disappeared.

When we examine more minutely to ascertain what has become of the substance which has been removed, we find it disposed of in the following ways.

The débris of the cancelli, and the other organic structures which were attached to them, are seen to be jammed for some little distance into the cells lining the track of the projectile. The wall of the cylinder has a comparatively even and solid appearance, and has lost much of its reticulated character; partly from the lodgment among its network of the minute fine disintegrated particles which have been displaced from the part now converted into a hollow cylinder, partly from compression and closer approximation of its own substance. If the bullet should have gone straight through, this condition will be equally marked over all the inner surface of the cylinder; if it should have passed slantingly, it is usually more marked on one side of the wall of the cylinder than on the other, proving that more pressure has been exerted in the one than in the other direction.

When a leaden bullet has not made an exit, but remains lodged in the cancellated structure, it is usually found to be firmly fixed in its place of lodgment. It is visibly scratched and roughened, minute particles of bone are held in some of the scratches, and no doubt the fixation of the bullet is partly due to the points and edges of the surrounding broken laminæ getting a firmer hold by these means. A smooth steel ball would probably be held less tightly under the same circumstances.

On examining the immediate neighbourhood of such a lodged bullet, we find a large portion of the particles of bone detached from the shot canal collected about it. The principal portion of the disintegrated tissue is in advance of the bullet; the compressed and compact débris, however, surround it fully up to its equatorial limits.

It follows from this examination that the tissue broken up

by the bullet in its course, and removed from its track, is partly forced into the walls of the cylinder formed by its passage, partly forced forward in front of it, and the inference is, that had the bullet passed completely through the bone, some of the osseous particles which are seen lying in front of the projectile must have passed out before it and have been dispersed. Indeed, we are aware that this does happen, for when the cancellated part of the bone is covered by muscular tissues, as in the shoulder, the gritty particles protruded from the shot canal can be felt in the soft tissues surrounding the opening of exit in the bone; and the same thing may be observed in a gunshot wound of the head, in which small bone fragments and particles will generally be found lodged about the track of the projectile in the brain.

If the bullet be one the surface of which is not liable to be scratched or indented, such as an iron one from a case or canister shot for example, and it has not passed out, the *cul de sac* in which it is lodged will perhaps be larger than the projectile, and the ball be found lying loosely in it. The increased size of the hollow place in which it is lodged may be due to the rotatory motion of the projectile having continued after its forward motion had been arrested, as elsewhere noticed; or, if the ball has remained lodged for some time, it may be due to movements of the projectile within the cavity it has formed for itself, accompanying changes in position of the whole limb. Specimens demonstrating these facts may be seen in the Museum of Military Surgery of the Army Medical Department at Netley. But, whether large or small, the surface of the cavity will be found equally to be compressed, and its cells filled with broken-up particles detached from other parts, so that a sort of lining is thus given to it.

When the bullet, instead of being spherical, has a conoidal front, such as a rifle bullet, the amount of bone carried before it will vary with the degree of bluntness of the apex. The blunter the apex the more closely the effects will correspond with those of the spherical bullet; the more pointed, the less of the débris will be pushed forward, and the more, in proportion to the width of diameter of the projectile, will be forced into the sides of the shot canal. The walls of this canal seem to receive a greater amount of destructive pressure from the conoidal bullet in its passage, and to be more seriously crushed, than when a spherical or obtuse-fronted projectile of similar diameter has passed through them with the same amount of momentum; the consequence being the production of a bone wound which is most difficult to heal, as every army surgeon who has had one under his care well knows. The peculiar mode of rotation of rifle bullets must be taken into account in estimating this result of their passage. In all the instances mentioned, however, the

abstraction and displacement of substance by the projectile are plainly shown.

When the projectile is a very narrow one, such as the Lee-Metford with a diameter of only three-tenths of an inch, and it passes through soft tissues only at a medium rate of speed, the track generally is so diminutive in size, so even and so direct, that it appears to have lost many of the characteristics of the tracks made by the cylindro-conoidal bullets in former use. The small size of the missile causes it to pass without touching many structures that could not have escaped if it had been an Enfield rifle bullet. The track, however, has the same features as distinguish that of an Enfield or Martini-Henry bullet, only modified by the smallness of the diameter of the projectile. The Lee-Metford bullet passes through the tissues with so much ease that it makes no effort, as it were, against the walls of its track while it traverses them, and thus their vitality is interfered with in a very minor degree. Portions of tissue are broken up and driven out, just as a portion of skin is removed or punched out at the wound of entrance; but the space left by the removal is so very small, that under the pressure of a slight amount of inflammatory swelling around the walls of the track, its calibre is still further reduced, its surfaces closely approximated, and hardly any perceptible vacancy is left. A track so diminutive in size, with its surface so comparatively normal in condition, will quickly become filled up, and cicatrisation take place without any interruption, under the simplest care and treatment.

Retention of air in bullet tracks.—Before quitting the description of the characteristic features of the internal parts of bullet wounds, the fact may be recalled to mind that when a bullet has made a comparatively superficial wound, especially when the track is tunnelled through the areolar tissue beneath the skin, air will occasionally be found to be retained in it. This is shown by a slight emphysematous crackling on pressure over parts of the track, and, if the bullet have passed out, by bubbles of air being mixed with the blood which may be squeezed out at the exit opening. The presence of air in such wounds can only be explained by its having entered the tissues at the same time as the projectile. Air probably enters on other occasions, when circumstances prevent the same evidence of its presence. The direction of the wound may favour the escape of the air by the same way it entered, or the depth of the wound may place it out of reach of observation, and thus the occurrence may elude notice. This subject has already been considered in some of its aspects when the views regarding projectile air in gunshot wounds were discussed (see page 69).

Tracks left by explosive bullets.—The construction of explosive bullets has already been described (see page 61). We have

very few surgical observations of the characters of wounds inflicted by them from their actual use in war.

Dr. Scrive, in his history of the Eastern Campaign of 1854–56, mentions that explosive bullets were employed by the Russian soldiers. According to his description, some specimens which were found at Sebastopol after the capture of the place consisted of a small cylinder of copper containing a detonating composition. They were made up in the form of cartridges, and were arranged for being discharged from ordinary muskets. The discovery of these projectiles, Dr. Scrive remarks, afforded a key for explaining some wounds of a frightful character which could not be accounted for by the action of ordinary bullets or fragments of shells.[27] Dr. Scrive does not describe the particular features of the wounds he alludes to.

I did not myself see any wound during the campaign which could be ascribed to the effects of an explosive bullet. Dr. Brush, surgeon of the Scots Greys, gave me the particulars of a wound in one of the troopers under his surgical care at the battle of Balaclava, which was attributed to an explosive bullet. The wound was in the popliteal region of the right leg, the edges were jagged and blackened as if burned by powder, the opening was large enough to admit two fingers, and Dr. Brush, on passing them downwards as far as they could reach, found the muscles of the calf reduced to a pulpy mass. The man was removed to the General Hospital at Balaclava, and the limb amputated, but unfortunately did not appear to have been examined after the operation. Dr. Crosse, of the 11th Hussars, also gave me the notes of a case which occurred at the same battle, and which he was led to believe had been caused by an explosive bullet. The wound was in front of the tibia, just below the knee, and the bone was shattered. The shock was so great that considerable time had to elapse before amputation could be performed. The pressure of duty at the time prevented a particular examination of the limb after its removal. Although the collection of projectiles in the United States Army Medical Museum at Washington contains specimens of the cartridges of Gardner's elongated shell bullets,[28] described at page 64, and of other explosive balls from the United States Ordnance Department, it does not seem that any illustrations of wounds known to have been inflicted by them have been preserved. Major Von Borcke, in his 'Memoirs of the Confederate War for Independence,' when describing an engagement near Fredericksburg in the summer of 1862, writes: 'In this combat I also saw for the first time exploding rifle balls used in action. They fell on all sides, bursting with a crackling noise in the trees and on the ground, without doing much execution.'[29] If we may judge from the few examples of them among the very large collection of projectiles extracted after flesh wounds, or after contact with bone,

in the Washington Army Medical Museum (only one such bullet and two metallic fragments, supposed to be parts of explosive balls, being noted, as far as I have observed in the catalogue [30]), these projectiles would not appear to have been much used by the armies of either the Federal or the Confederate States.

The effects of some conical shell bullets, invented by Major Fosbery, were tried during the Umbeyla Campaign on the north-west frontier of India in the year 1863. They were fired from Enfield rifles. Major Fosbery had with him thirty-two marksmen selected from the 71st and 101st Regiments, who were employed for several weeks on outlying pickets or with skirmishing parties, and used these explosive bullets. The military results of the experience gained from their employment were published,[31] but I have been unable to obtain any observations on the characters of the wounds produced by them from the surgeons who were present on this occasion. The opportunities of examining them were probably very limited in number, as the mountain tribes against whom the bullets were used succeeded in removing a great proportion of their dead and wounded from the scene of conflict. A non-professional writer in the *Times* newspaper, when writing on the military results of the explosive bullets in this war, mentioned that a few wounds came under his observation, and remarked that 'in one instance the bullet had entered the back of the neck, and then exploding, had entirely blown away the face; while in another, where the bullet had struck just over the heart, the effect was even more terrible to witness.' [32]

In consequence of the absence of reliable information respecting the characters of wounds inflicted on men by explosive bullets, and the repeated allegations of their employment that have been made in recent wars by the opponents on both sides, I thought it might be advantageous, as a guide to what might be expected to follow their adoption among combatants, as well as for affording means of testing suspected instances of their employment, to collect some information on the principal features of the wounds inflicted by them on the lower animals. Several of the best known sportsmen in India kindly assisted me in my inquiries. The result of the investigations may be summed up as follows.

When an explosive bullet bursts within a cavity of the body without striking bone, the bullet is sometimes simply torn asunder, but is sometimes rent into many scattered pieces. The viscera of the cavity are generally torn to pieces or in a measure pulpified. If examined early, the cavity is found to be filled with grey smoke, wreaths of which often make their way out from the wound of entrance. The escape of puffs of smoke from the wound, when the projectile has burst fairly within a part of the body, lasts for a considerable time after its infliction if the wounded part be subjected to movement, and is quite characteristic of the special means by which

the wound has been produced. The ribs, the spine, and even the bones of the pelvis and of the extremities of the most powerful savage animals, are liable to be broken by explosive bullets. When the shell bursts among muscles, a huge gap from 4 inches to 6 inches in diameter may result, the soft tissues being reduced to a jelly-like mass. The surrounding structures exhibit signs of being burned, the degree of burning being very varied. Explosive bullets, however, frequently pass through the muscular tissues, and only explode on striking bone. The bones sometimes escape fracture when they have apparently been struck, but they are often found smashed to pieces. When the bullet explodes in a limb, blood is widely extravasated and is forced between the muscles to a great distance beyond the principal area of destruction, frequently dissecting them, as it were, from one another. There is also considerable emphysema from gas being forced into the areolar tissue. The muscles for a long distance are darkened in their substance, and appear as if they had been contused. Decomposition takes place speedily in the parts around the site of explosion. A sulphurous odour pervades the tissues: this arises from the fact that the explosive mixture used in India has ordinarily consisted of sulphuret of antimony and chlorate of potash. Injuries from explosive shells, even where they do not inflict wounds of a fatal character, are almost invariably attended with great shock to the nervous system. Explosive bullets, as hitherto made, have been very uncertain in their effects, sometimes exploding on first striking the surface, sometimes passing through without exploding at all, sometimes almost entirely destroying the animal hit by them, so that their employment is now discarded by most sportsmen.

The construction of various explosive bullets, and the nature of the agreements arrived at by the chief military Powers regarding their use in war, have been explained in a previous chapter (see sect. 1, Chap. V.).

CHAPTER IV

CHARACTERISTIC FEATURES OF INJURIES BY SMALL SHOT

Circumstances which modify the characters of injuries by small shot.—Small shot fired from sporting or smooth-bore guns produce injuries which differ very materially in their appearances and their nature, according to the distance from which the shot have been discharged, their size and number, the charge of powder, the kind of cartridge employed, and the quality of the fire-arm. This is the result of the fact that on leaving the muzzle of the fire-arm, the shot, whatever their sizes and weights, assume the

outline of a diverging cone, of which the 'spread' or degree of divergency varies according to the different circumstances above enumerated. A description of the sizes and weights of the various kinds of 'Small Shot' in general use will be found on page 65.

When the fire-arm is loaded, as it used always to be in former days, by pouring the shot on the wad which keeps down the charge of powder, the shot are more scattered than when they are fired from machine-made cartridges, such as are now in common use with breech-loaders. One effect of the modern cartridges is to keep the shot more together, and to cause them to maintain this mutual proximity to longer distances. The results of some trials on this point are described in the Appendix.[33]

Small shot fired close to the body.—If the weapon be held so close to the surface of a limb or part of the body that the wad and shot enter together in a mass, and no bone intervene, a large proportion of the charge will probably pass deeply into the wounded part or completely through it. The vacant opening left by the entrance of the shot presents much the same general aspect as it would if it had been made by a single projectile. The track speedily becomes enlarged as it proceeds from the entrance wound, owing to the shot diverging and separating from each other; the soft tissues bounding the track are much lacerated, in parts are torn into shreds. The wound of exit, when it exists, is much larger and more ragged than the wound of entrance, and its borders are everted. Isolated shot sometimes form openings round the principal aperture of escape; but whether they occur, as well as their number and extent, will depend upon the distance at which the exit is effected and the nature of the tissues through which the shot have passed. If through a fleshy part of moderate thickness, and the exit wound be relatively near to where the shot entered, it will be large and greatly torn, owing to the spread of the shot, and some of the wounded tissues being carried along with it through the exit opening; if the opposite surface be relatively distant, many of the shot will be caught on the way, and broken-up tissue will not find the same means of escape through the exit aperture. The entrance wound, too, if the weapon be held close to the body, will also be attended with a certain amount of charring and blackening from the effects of the flame and smoke, similar to what would accompany a bullet wound under like conditions. The rending and contusing effects due to the blow and expansion of the volume of gas from the exploded powder would be alike under the circumstances named, whether a charge of shot or solid bullet had been the cause of injury.

If the shot meet the shaft of one of the smaller bones, such as one of the long bones of the forearm or a rib, when the shot has been discharged from a fire-arm touching or close to the body, the bone will probably be shattered, and the destruction of the

surrounding soft parts will be still greater, because of the deflection of the shot. Most of the shot which do not lodge in the broken bone are scattered around on all sides, tearing up the tissues into which they have been driven. Some shot and some of the fragments of bone will probably be driven out through the opposite side of the limb, causing torn and irregularly shaped wounds in that direction. If the bone be over a cavity, as in the instance of a rib, the principal part of the charge of shot, and perhaps some of the fragments of bone, will penetrate, and spread through the substance of the organs within. A few stray shot will not improbably pass to a distance beyond the wounded viscera, while some will remain in the substance of the bone itself, and some others be deflected and lodge in the adjoining muscular parietes. In such a case there is rarely any wound of exit.

If the charge impinge upon bones in which the cancellated structure prevails, as among the bones of the tarsus for example, although the bones may not be broken, a large proportion of the shot will become deeply imbedded and remain lodged in their substance. The extent to which the shot may be disseminated under such circumstances may defeat all attempts to repair the injury. A charge of No. 4 shot fired a few inches off entered the right foot of a soldier two inches in front of the outer malleolus, and made an exit close to the inner malleolus. Attempts were made for a long time to save the foot, but in vain. Nearly two years after the date of the injury the foot was amputated at Netley, when not only the astragalus, but also the os calcis, scaphoid, and cuboid bones were found studded with shot throughout their entire texture.

Charge of shot fired within a foot from the body.—If the fire-arm be discharged from a distance not greater than twelve or perhaps fourteen inches, or at any less distance from the surface, and the shot are of moderate size, they will still enter in a mass, but the opening will be larger and the edges more lacerated than when the fire-arm is quite close to the body. In a case in which a charge of shot entered the thigh rather obliquely from about the distance named, the entrance opening was an inch and a half by one inch in size. No detached shot will be scattered around the principal opening, or but very few will strike separately.

Charge of shot fired at about five yards' distance.—Beyond a foot and up to about five yards, a portion of the shot, presuming the surface struck to be uncovered, or only covered by light clothing, will still enter in a mass, inflicting a central wound, around which there will be other wounds from scattered shot. Woollen clothing or any covering of such substance will of course modify the effects, according to its nature and toughness. The wound will be very irregular in outline, with its borders scalloped by the shot, and generally inverted. The number of shot which wound

in a mass, the number which are scattered around the wound and become lodged in the tissues, and the extent of surface over which they are scattered, will all vary as the distance is varied.

So long as there is a large and complete open wound bearing a resemblance to a bullet wound, the explanation is to be found in the fact that it is not inflicted by a single layer of shot, as it were, but by successive layers. Shot behind closely follow those in front, so that not only are openings made by the shot which first strike, but any tissues that may have remained to connect these openings are broken up and other openings produced by the shot which follow. The whole of the tissues of the part thus rained upon are completely destroyed, and an open blank remains. When the shot have diverged to a certain extent, all the shot travel in different paths, and they then strike singly, and as a rule, unless a shot happens to strike an important part, as the eye, without any serious results.

Charge of shot fired beyond five yards' distance.—Beyond a range of five yards there will probably not be any central wound, but still, if the fire-arm be not far removed from this distance, a proportion of the shot will be more closely congregated at a spot corresponding with the line of fire than elsewhere. The rest of the shot will be scattered, sometimes two or three together, but generally at increasing distances from each other as the distance from the centre of collision is increased, and from the slanting direction in which they strike and pierce the surface and underlying parts, will almost invariably remain lodged. The distance to which they penetrate will of course depend on the force retained by the shot, the nature of the tissues penetrated, and the resistance, always relatively great, made to the progress of each of the small, obtuse, and usually flattened shot concerned.

Charge of shot fired from about fifty yards.—At a distance of fifty yards some shot will still retain sufficient energy to enable them to penetrate the surface, but they will usually not sink beneath the fascia. They are commonly found imbedded in the subcutaneous areolar tissue, whence they can generally be extracted without difficulty immediately after the infliction of the wound. If not extracted, under the circumstances named, simple shot rarely give rise to local irritation: the opening through which it entered soon becomes closed, and the shot remains quiescent. It probably becomes encysted.

Effects of small shot on blood-vessels, nerves, and some other organs.—The divergent laceration caused by small shot within short ranges has an important bearing when the shot passes through structures in which vessels and nerves of large size are contained. A vessel which might possibly escape division by yielding to the pressure of a bullet passing through the adjoining tissues has scarcely any chance of avoiding laceration or

serious contusion when a small shower of shot from a fowling-piece is fired in its direction. Tendons and ligaments are equally subject to irreparable destruction under the same circumstances. A charge of shot through the wrist or forearm will rarely leave much scope for any conservative proceedings. Similarly destructive results usually ensue when charges of shot have force enough to pass into cavities of the body and to traverse any of their contained viscera. Such penetrating wounds are almost inevitably fatal. There are various chances of escape, even though a small bullet may perforate the abdomen, or penetrate the chest and pass through a lung, but scarcely any with a charge of shot under like circumstances. The cone of divergence is usually increased in diameter by the effects of the passage of the shot through the wall of the cavity, and the involved viscera are consequently penetrated in numerous directions; the tissues intervening between the openings are extensively rent and bruised; and single shot diverted by accidents of impact in passing through the wall of the cavity penetrate other organs at various distances from the principal focus of damage. The walls of wounded cavities are also themselves often extensively injured beyond the site of the chief wound, for some of the shot in passing through the several layers of which these walls are composed, especially when some of them are tendinous, are apt to be deflected, to travel separately at various angles to considerable distances, and thus to widen the area of injury.

Wounds by small shot entering singly.—A single shot which has lodged superficially is usually of trifling importance. If it be lodged in the face, and its removal be desirable, its extraction is easily effected. The safety of eyesight is hazarded if one lodge in the eye, however superficial the lodgment may be; if it lodge deeply in the organ, the removal of the eye is a matter of almost inevitable necessity. If a small shot penetrates so deeply in any part of the body that it is lost to view, search for it can hardly ever be advisable. Its minute size, and the readiness with which it may be deflected and lie concealed in parts remote from the orifice of entrance, would necessarily lead to very great difficulty in discovering it. Even when careful examination is made after death, the place of lodgment of an isolated shot of the kind is rarely discoverable. The external marks of a wound by a single shot may be so slight as to be unnoticed, although search is made for it; and still less would its track admit of being followed. Yet cases have been recorded in which fatal consequences have resulted from the entry of even such a small projectile as this. The brain has been penetrated by a shot through the orbital plate of the frontal bone, the aorta through the chest, and death in each case has been the consequence.

Rased wounds from small shot.—When a charge of shot

fired close at hand traverses superficially some part of the surface of the body, the integuments and some of the muscular structures beneath will be excavated and carried away, and a lacerated and contused wound with much surrounding ecchymosis will be presented to view. Some of the shot are generally caught and imbedded in or near the surface of the wound. The integument bounding the gap effected by the shot is torn irregularly, separated to some extent from the subjacent tissues, blackened, and hangs about, showing that it is deprived of its usual elasticity, and to some extent of vitality. If nerves and arteries have happened to be in the way of the shot, they also are torn, and generally in part shot away. The effects of a rasing charge of shot, such as that just described, necessarily become modified as the distance of the point of discharge is increased, in the same way as has been described with regard to point-blank wounds.

When part of a charge of shot fired from a considerable distance has penetrated the surface slantingly, it may still be expected that some of them will travel to long distances from the wounds of entrance. The shot cleave their way very readily through the connective tissue which binds the muscles or other organs together. The readiness with which this happens is one reason why these slanting wounds so often give rise to troublesome complications and require prolonged treatment.

Effects of small shot on parts covered with clothing.—When a charge of small shot enters a part of the body which is covered by clothing, the shot generally carry some fragments of cloth in with them. They do this, indeed, more commonly and more extensively, in proportion to their size, than larger projectiles, such as rifle bullets.

A spherical or cylindro-conoidal bullet, when it penetrates a part of the body covered with clothing, especially when the clothing has been put upon the stretch, as happens with a sleeve of his tunic when a soldier's arm is bent in front of him, or with the upper part of his trouser when he is kneeling, usually punches out a portion nearly corresponding in shape and size with its own circumference. But if the velocity of the spherical projectile be lessened, or if the clothing which covers the part it happens to impinge upon be free and loose, or if the bullet be one with a narrow diameter and tapering front, the accident of a portion of the clothing being detached and carried onward by the projectile is frequently avoided. The cloth or linen is pushed forward by the projectile for a certain distance, when its fibres yield, an opening is made, and through it the bullet pursues its course.

With small spherical shot the case is different. The shot, being fired in close contact, often lose their round form and become more or less flattened against one another, in consequence of the character of the force impressed upon them at the time of

their discharge from the fowling-piece. Their penetrative energy is thus lessened. The shot do not severally pierce the covering, or punch out a portion corresponding in size to themselves, but each presses before it and tears away a small portion rather larger than itself of the woven material opposed to its passage; or, when two or more shot strike very near each other, they carry away not only portions directly opposite to them, but also some of the intervening cloth by which those portions were connected.

The amount of the covering carried away, however, will depend upon the kind of clothing, whether it be of a texture that parts asunder readily, or whether it be tough and elastic. A charge of shot passing through the upper leather of a boot and through a stocking into the foot may not carry any of the leather into the wound, unless it is fired close to the foot, so that the shot enters in a body, *en balle,* as the expression is, but it will almost certainly carry fragments of the stocking into it. This happened in the case of the shot wound of the foot referred to on page 192. The soldier had a Wellington boot on when he was hit, and the charge entered through it. Some of his cotton stocking was carried into the wound, but none of the leather. The back of the boot was not cut: the portion of the charge which passed completely through the foot was found mixed with coagulated blood in the boot itself. In a case which fell under my care in which a charge of very small shot, such as is specially used for killing birds for natural history collections, was accidentally fired close to the foot, the muzzle of the gun being probably only two or three inches from it, a circular piece of the comparatively soft upper leather of the boot, as well as a fragment of the sock, were carried into the foot. The chief part of the remaining force seemed to be expended upon one of the metatarsal bones, which was fractured, for none of the shot passed out through the sole of the foot. They were concentrated in greatest number around the seat of fracture; but others were dispersed in all directions among the lacerated soft textures of the foot.

SECTION IV

ON THE PRIMARY SYMPTOMS AND COMPLICATIONS OF GUNSHOT INJURIES

Introductory remarks.—In the preceding section the local physical effects of the strokes of projectiles have been described; in the present section the primary symptoms or early phenomena which usually attend the production of these effects, and certain complications with which they are liable to be accompanied, will be particularly noticed.

The *symptoms* which frequently attend gunshot injuries are (A) pain, (B) shock, and (C) primary hæmorrhage. (D) Thirst so generally exists in an intense degree among men suffering from gunshot wounds on fields of battle, that it may also be regarded as one among the other symptoms of such injuries. The primary *complications* of gunshot wounds which will be described are (E) lodgment of foreign bodies, (F) burns, and (G) multiplicity of wounds.

CHAPTER I

(A.) ON PAIN AS A PRIMARY SYMPTOM OF GUNSHOT INJURIES

Causes which modify this symptom.—The amount of primary pain which accompanies the infliction of a gunshot wound, more particularly one by a bullet, varies very greatly in degree according to the kind and situation of the injury, together with the condition of mind and the state of constitution of a soldier at the time of being hit. It is not, as a general rule, a symptom which affords any reliable indication of the nature or degree of gravity of the wound which has been inflicted. In very severe wounds from projectiles of considerable size, pain is usually deadened either by annihilation of function and sensation of the parts wounded, or by the state of stupor into which the shock of the injury has at once thrown the patient. In occasional cases of nerve injuries, pain is extremely intense from the first, and continues so unless relief be afforded, so that this symptom

itself becomes a source of danger to the patient. This occurs, however, only in very exceptional instances. In most cases the early pain, even if severe, is very evanescent, is followed by a certain amount of numbness, and only recurs after reaction sets in.

Various degrees and kinds of pain felt by wounded men.—Wounds that are directly mortal are sometimes accompanied by a loud shrill cry at the instant of their infliction. The utterance of this piercing exclamation, distressing to comrades as it is to hear it, and all the more so from the mutilation and other startling circumstances with which it is often associated, can hardly be regarded as an indication of conscious suffering. It is probably analogous in its nature to the cry of the hysterical, the spasmodic scream which attends destruction of life by prussic acid, and to the yell of the epileptic as he falls to the ground.

In other instances in which this directly fatal character does not exist, temporary loss of consciousness immediately follows the infliction of the wound. The patient totters and falls, bereft of sense, and in that condition remains for a longer or shorter time according to circumstances. When this occurs, although the infliction of the wound may have been attended by instant pain of a severe character, no recollection of it is afterwards retained.

In cases where loss of consciousness does not follow gunshot wounds, the accompanying sensations may or may not be noted by patients; and when noted, the impressions entertained of its nature and character will be found to differ most widely. It may be readily understood why such discrepancies should occur.

The extreme suddenness of a gunshot wound, its startling nature when its infliction is perceived, and the previous occupation of the soldier's thoughts, probably intently engaged on some of the exciting scenes around him, may well prevent him from observing and noting his sensations at the moment of being wounded with any approach to accuracy. The occupation of the mind may be so intent in other directions that the passage of the bullet may not be noticed at all. Soldiers who are the subjects of simple flesh wounds will frequently tell surgeons that they were not aware when they were struck. The truth of these statements is confirmed by the fact that instances are not rare of soldiers continuing in action after they have been hit. Men in a state of excitement, especially when over-stimulated by the close proximity of their enemy, have been often known to fire several rounds after having been wounded, only leaving off when faintness and a feeling of nausea from loss of blood have occurred, and compelled them to desist from exertion; or when accidental observation of the blood proceeding from their wounds has made them acquainted with their condition. Had they been previously aware of what had happened, they would have ceased to fire and sought for help. The fact that the very part which has been wounded was at the same time

engaged in some active exertion may help to divert the mind from taking notice of the pain accompanying the wound. Thus a man receiving a flesh wound of the arm while in the act of firing his rifle may mentally attribute the sensation, really due to the entry of a bullet, to the recoil of the weapon at the time of its discharge; or he may connect it with something that is happening in his immediate neighbourhood which might produce a feeling of pain similar in character to that which has been caused by the projectile. A soldier of the 23rd Regiment was wounded at Amoaful during the last Ashanti war near the bend of the elbow. He was in the act of loading his rifle under the shelter of a tree when he was hit. He felt a blow as if he had been struck by a stick; pieces of branches were being knocked off around him, and the impression on his mind at the moment was that one of these pieces had fallen and struck him, and he then thought no more about it. After firing his rifle three times, the captain of his company, who was standing by and saw blood coming from under his coat-sleeve, told him he had better go to the rear as he was wounded. The man himself was not aware of the fact until the officer informed him of it, although, as it turned out, a slug had passed deeply into the arm. Sometimes a soldier will have received two or more wounds, and be only aware of the occurrence of one or other of them according to circumstances. Instances are not wanting in which an important bone even has been broken,[1] and although the occurrence has been accompanied with a violent shock, the pain has not been such as to make the soldier conscious of the severe wound which has happened to him. Under the excitement he has attributed the shock to some other cause, and has only become aware of what has really happened when the limb to which the broken bone may have belonged has dropped from its support, or on making some exertion which has led to his fall, and so betrayed the nature of the injury to which he has been subjected.

Effect of velocity on pain.—Perhaps the occasional unconsciousness of the passage of a bullet through organised structures may be not merely due to the fact of important nerves having escaped collision and injury, but may also be accounted for by the projectile having been armed with nearly its highest rate of velocity at the time of making its transit. The bullet has travelled through the parts almost as instantaneously as a flash of lightning. Practically it has not encountered any opposition in its path, especially if it be one of very narrow diameter, and its progress has been unaccompanied by transmission of violence to the surrounding structures. It has been stated in the descriptions of some accidental wounds by modern armoured bullets, that their passage has not been known at the time to the men wounded. It has been elsewhere shown that the Martini-Henry bullet travels the first 400 yards of its course in one second; supposing it to pass

through six inches of the fleshy part of a man's arm at the same rate, it would traverse the part in $\frac{1}{2400}$th of a second of time. A bullet from the Lee-Metford rifle travels at far higher speed. Under such circumstances it may well happen that no knowledge is obtained by a wounded man of the sensations which really attend the passage of the projectile, because there is not time for the local impressions made at the instant of its transit to be conveyed to the brain.

Descriptions by patients of the pain of gunshot wounds.— As a general rule, however, the patient is alive to a certain amount of pain accompanying the forcible entry, or more especially the exit of a bullet, even in uncomplicated flesh wounds. Occasionally this pain is described as having been like a flash of fire; or like the sharp stinging pain from a sudden smart stroke of a cane; or, in other instances, as the shock of a heavy, intense blow. The idea of a hard bruising blow seems to be one of the most common when a gunshot missile penetrates the flesh. 'Like a hit from a sledge-hammer followed by a burning sensation,' was the account given by one man of what he felt at the moment of being wounded by a Lee-Metford rifle bullet.

The stroke of any gunshot projectile by which a flesh wound is inflicted appears to be more severely felt when the parts struck are under the influence of muscular effort than when they are in a passive or semi-relaxed condition. If a man when wounded is in the act of walking, and the missile happens to strike the limb which at the moment is sustaining the weight of the body, the blow will probably be heavier and the shock greater than if it had passed through the corresponding parts of the limb which is merely being swung forward to take the place of the other limb in progression. In the former case the man will probably fall—be 'knocked over'; in the latter, though the pain may be severe, the man will probably be able to maintain his balance. So if the man be in readiness to discharge his rifle, the force of the stroke of a bullet, if the man be alive to it, is likely to be more painfully felt in the arm which is about to pull the trigger, and the muscles of which are in strong action, than it would be in the arm which is only bearing the weight of the rifle. The suddenness of the interference with the act which was in progress may add to the sensory effect by exciting the attention more acutely to the circumstances of the wound and its attendant pain. The shock experienced on the mind being roused to the occurrence of the injury may also increase the effect produced on the wounded man.

General Sir C. Napier was an accurate observer as well as a vivid narrator of events. When in his sixty-second year of age he was wounded by a fragment of the shell of a rocket which burst while being tried at Kurrachee in 1842. His description of

the wound was: 'I felt a *severe blow on my leg*, yet did not fall, and, looking down, saw that a splinter had torn my trousers to pieces, and the calf of my leg also. The wound was horizontal, three inches deep and four long, or rather more; it cut clean through the calf and was ugly to look at.' [2] But the descriptions given by patients of the character and amount of pain they endured from their wounds will always much depend on their personal peculiarities in regard to temperament, education, and habits. At the same time it should be remembered that very dissimilar degrees of pain are really experienced by different individuals from wounds similar in nature and extent, owing to differences in their physical organisation. Surgeons who had to do with amputations of limbs prior to the days of anæsthetics had frequent opportunities of observing such specialities of sensory constitution.[3]

Of pain at the wound of entrance of a bullet.—Sometimes, without a distinct manifestation of local pain at the moment of being struck, there is still a consciousness of some injury being received in the neighbourhood of the wound of entrance. A blow or shock is felt at the part, and the man concludes that he has been wounded, but does not know precisely where the wound is till he looks for it, or the appearance of blood indicates its situation. Occasionally, when the local pain is distinct and sharp enough, its peculiar character leads the man to attribute it to some cause which usually gives rise to it, and not to the effect of shot, notwithstanding he is under fire, and that therefore the probability of his receiving a wound might be expected to lead him to attribute every sudden painful sensation to injury from a missile. A hospital sergeant, who served with me, had been wounded in the leg by a musket ball at Calpee. The bullet passed through his trousers, and caused a small rasing wound a little above the ankle, and about two inches in length. The sensation given was precisely as if some insect had stung him. He brushed it away as he thought, and went on with what he was doing; but presently the warmth from the blood flowing within his sock attracted his attention, and the wound was discovered.

Pain at the wound of exit of a bullet.—In some instances no pain is noted at the entrance wound, but is distinctly felt at the wound of exit. A private of the 7th Fusiliers was in face of the enemy at Inkerman. A bullet pierced the lower and outer part of his neck, and tore its way out behind, between the upper angle of the scapula and the spine. An officer of the 2nd Batt. Rifle Brigade was behind him. No idea of having been shot entered the private's mind. He was not even aware of the wound he had received in front, but his sensations led him to suppose that the officer behind had pricked him with the point of his sword in the back. He turned round instantly to learn what this was done

for, and was in time to see the officer in the act of falling. The bullet which had just passed through his own neck had struck the officer in the head and killed him. I have heard my father refer with amusement to the sudden anger of another officer in front of him, who, on some occasion of effecting a landing before an enemy, was hit by a bullet through the fleshy part of the thigh while the party were advancing on the sea-beach. He had no idea at the time that he had been shot, but turned round in a rage, on the supposition that some one had struck him a sharp blow from behind. Similar instances of the stroke of a shot being mistaken for a blow from a neighbour have been related to me by men who have been wounded. Curiously enough, in such cases the momentary impression seems usually to be that the blow has come from somebody in rear, so that the chief part of the sensation has probably been derived from the wound of exit. With regard to the bullets of former days, this may have been due to the lessened velocity of the bullet, and greater stretching and tearing of the sentient surface at the place of its escape. In some instances of men who had been shot through the chest from before to behind by Remington rifle bullets in the advance upon Tel-el-Kebir in 1882, and who were invalided to Netley, the patients were fully persuaded they had been shot by some of their own comrades in rear of them. They had felt the blow when the bullet struck them in the back, they each said. But the circumstances when investigated, the conditions of the respective openings left in their tunics, as well as the characteristic features of the cicatrices, sufficiently proved there was no ground for their suspicions, and that they had received their wounds from the fire of the enemy in front. Such references of pain to wounds of exit may not occur when the wounds are inflicted by the new small-bore rifle projectiles, owing to their increased speed of flight and great penetrative energy preventing any appreciable difference in their action at either opening, whether entrance or exit.

Pain along the tracks of bullets.—In simple flesh wounds, and in all wounds in which important nerves and bones are not struck, when pain has been felt and has been noted, it seems generally to have been referred to one or other of the surfaces, either at the wound of entrance or that of exit. Even in cases in which the velocity of the projectile has not been very great, and it has not made a wound of exit, but has lodged under the skin at some point opposite to that at which it entered, pain along the track of the wound is not commonly remembered. A wounded man, when speaking of the pain caused by his wound, usually refers to it as *on* the wounded part, not *in* it. If pain should have been felt as the projectile passed along its track, it has been so instantaneous, and has been so speedily followed by local

numbness, by more or less loss of sensibility in the part, that the primary symptom of pain is forgotten. A feeling of heaviness, often likened to the parts concerned having been stunned, is usually complained of, and this sensation may extend to a considerable distance from the site of injury, perhaps to the whole limb, if the wound be in the upper extremity. The following is the only instance I have met with in which there appears to have been consciousness of pain throughout the course of the bullet—at the entrance, along the track, and at the exit. The patient was a medical officer, Dr. Chalmers Miles, who was shot during the Sepoy Mutiny in an attack on a fortified place not far from Neemuch. The description of the wound is in Dr. Miles's own language. 'Just about this time I was shot through the thigh by a bitten musket bullet—one of those implements of war which cause immensely unpleasant and jagged wounds. The feeling when you are hit is peculiar: it is just as if a red-hot iron was suddenly plunged into your thigh, and the channel it formed filled with molten lead; then a scalding, unpleasant pain passes through you; and then there is a sensation of faintness, yet relief, and the ball is out.' [4]

Pain of bullet contusions.—When a bullet does not penetrate the flesh, but simply inflicts a contusion, the pain caused by the injury is often described by patients as having been more severe than the pain spoken of by patients in whose bodies the bullet has effected an entrance. In such cases, in addition to the direct injury to the sentient nerves of the skin, and to the sub-tegumentary tissues, at the particular spot struck, the extent to which the impetus is communicated to the parts surrounding the point of impact of the bullet, and the great stretching to which these parts must be subjected, must also be taken into account in explaining the severity of the pain complained of. In a wound made by a bullet moving at full speed this strain upon the surrounding tissues can hardly take place, for the resistance of the parts opposed to the projectile is instantaneously overcome and a passage freely opened to it. The sensitiveness of the skin at the wound itself is at the same moment numbed, or, it may be, even annihilated, by destruction of its vitality.

Special sensory effects from injuries to nerves.—Occasionally, when the trunks of nerves are directly injured—not divided, but violently pushed aside—the wound will be accompanied with intense pain, but none will be experienced locally; the pain which is felt will be referred far away from the track of the projectile to some distant part to which the nerves are distributed, or for an instant a portion of the limb will be thought to have been completely carried away by the shot. I have known a wounded officer in the Crimea so deceived from the cause mentioned as to support an unwounded arm a considerable distance, on the supposition

that his hand and forearm had been shattered by a shot. He had been wounded through the neck, but was not aware of having been struck in that situation. It has happened that a patient who has sustained a wound, in which nerves have been implicated, in one limb, has thought that the wound was in the opposite limb. Dr. Mitchell, of the United States, has mentioned two cases in which wounds of one leg seemed to the patients to be really in the unwounded limbs,[5] and has referred to other cases of a similar nature. Less rare cases are those in which pain is not only felt in the wounded limb, but reflex pain is also felt at the same time in the opposite uninjured limb, in parts corresponding in function with those at the true seat of injury.

CHAPTER II

(B.) ON 'SHOCK' AS A PRIMARY SYMPTOM OF GUNSHOT INJURIES

Description of shock.—When a large bone is suddenly shattered, a cavity penetrated, an important viscus wounded, a part of the body struck by a heavy fragment of a shell, or a limb carried off by a shot, one of the most common features of the injury is a general disturbance of the nervous system, which shows itself by strongly marked bodily and mental depression. In most cases this perturbation supervenes instantaneously on the injury. This symptom is generally described as the 'shock' of a gunshot wound. The patient trembles, totters, is pale, depressed and faint, perhaps vomits. The surface of his body has lost its natural warmth. His features exhibit the vacancy of stupor, and more or less anxiety and distress. His circulation is weak, irregular, and agitated; the respiration feeble, slow, and labouring. It seems as if every mental and bodily function of the patient had received a sudden check. A somewhat similar emotion or state of agitation and apparent stupor may be observed in a horse which has received a serious or deadly wound in action, just the same as in his rider. It may be regarded as an expression of sympathy of the whole frame with a part suddenly subjected to serious injury. The prostration of shock must not be confounded with the prostration or collapse which results from copious loss of blood. The instant tottering and trembling condition of the body, the direct depression, and the immediate stunning of the senses which are so characteristic of shock, are hardly noticeable among the early symptoms of faintness from hæmorrhage. At the same time, as both drain of blood and nervous shock produce many similar results, though by different paths, on the centre of circulation, there are necessarily many symptoms in common between them.

Neither should the effects of shock be confused with those produced by direct injuries of the brain or spinal cord.

Variations in degree of shock.—The shock of a gunshot wound is more or less marked in degree according to various circumstances. Examples show that it may occasionally be altogether suppressed for a time, even in very severe injuries, by moral and nervous action of another kind, or by a state of mental tension; but this rarely happens when the injury is a vital one. One difficulty in estimating the amount of shock in particular cases is that panic, when induced suddenly, leads to symptoms which closely simulate those of traumatic 'shock.' A soldier having his thoughts carried away from himself, his whole frame stimulated to the utmost height of excitement by the continued scenes and circumstances of the fight, when he becomes conscious of being wounded, is instantaneously recalled to a sense of personal danger; and if he be seized with doubt whether his wound is mortal, depression as low as his previous excitement was high may immediately follow. This alarm, and the depression induced by it, will vary in degree according to individual character and intelligence, state of general health, the structural condition of the heart, whether vigorous or weak, and other personal peculiarities. In persons enfeebled from any cause, from previous illness, the injurious effects of a prolonged campaign, unhealthy surroundings, as when men have been shut up for a long time in a besieged place, from bad and insufficient food, over-fatigue, and other such causes of physical depression, the shock of a gunshot wound when it occurs will be more profound, and the reaction from it more delayed and difficult. If the emotion be as intense as it is sudden, it alone will sometimes induce a rapidly fatal result. In others of a different temperament, the alarm and depression will be controlled, and even extraordinary energy be manifested in its stead for a time. Numerous examples occur in every action of men walking long distances to field hospitals for assistance, unsupported and with comparatively little signs of distress, after a gunshot fracture or even the loss of an arm, a perforating flesh wound of the thigh, or some other such severe injury, and only, after arrival at a dressing station or field hospital, exhibiting the usual symptoms of shock. Among the collection of drawings by Sir Charles Bell at Netley, is one of a sergeant of cavalry who had his left arm completely carried off near the shoulder by a large cannon shot at Waterloo; yet in this condition he started off and rode upright all the way from the field of battle to Brussels, a distance of fifteen miles. Such a remarkable feat could only have been accomplished under the influence of extreme nervous excitement. On reaching a ward in the Elizabeth Hospital, he became utterly prostrate, and remained insensible for half-an-hour. His collapsed condition was readily

explained by the fact that the stimulus which had urged him onwards had suddenly ceased, and that the exertion he had undergone in his wounded condition would necessarily be followed by extreme bodily fatigue. On the other hand, examples might readily be quoted of men with comparatively slight wounds who have been quite overcome and have had to be carried from the field. It is not easy in many of these latter cases to determine how much of the symptoms presented is due to alarm, and how much to true 'shock.'

Duration of shock.—The duration of shock, when it exists as a temporary condition—that is, when it is not associated with any fatal shot wound—is as varied as is the degree in which it is met with at the onset of the injury. It may pass off in ten or fifteen minutes; it may remain four or five hours, or even longer, and then pass away. Nor can the period during which it will last be calculated from the amount in which it is exhibited immediately after an injury. Excessive shock will sometimes pass off with comparative quickness, while the persistence of moderate shock is often very prolonged. These differences, again, seem to depend upon constitutional peculiarities; perhaps on the extent to which the centre of circulation is susceptible to the influence of the nervous system, perhaps to the fineness of the sympathy which exists in the ganglionic system. They cannot always be explained by the relative degrees of gravity of the wounds themselves.

Recovery from shock.—As the shock is disappearing, the pulse gradually resumes its regularity; the paleness changes to the natural hue as the capillary circulation of the surface of the body is restored; the mind gradually regains its power, awaking, as it were, from a state of abstraction and of general undefined apprehension to take a discriminative interest in the local injury which has been sustained, and to consider its nature and consequences with judgment. Even moderate uneasiness and pain at the seat of injury become noticed by the patient. In short, a gradual improvement, bodily and mental, takes place until the normal state of tranquillity is restored, and nothing remains beyond the particular local disturbance which has been directly produced by the violence of the shot.

Effects of shock on hæmorrhage.—One effect of shock is to lessen the impulse of the heart's action, and thus for a time, like fainting, to lessen the risk of fatal hæmorrhage in case of an important artery having been opened. But equally with what happens in fainting, as the heart recovers its vigour, and the circulation recovers its usual force, so the danger of a return of hæmorrhage is increased. The reaction of shock is very similar to the reaction of faintness, though arising in different ways. The necessity for watching the return of bleeding under such circumstances, and for being prepared on the instant to check it, is

a matter that should not be forgotten when a wounded man has to be intrusted to imperfectly trained bearers during removal from one place to another, or is left in the hands of inexperienced hospital attendants.

Relation of shock to amount of injury.—As a general rule, the graver the injury the greater and more persistent is the amount of shock. A rifle bullet which splits up a long bone into many longitudinal fragments inflicts a much more serious injury than the fracture which was ordinarily produced by the ball of the smooth-bore musket; and the amount of constitutional shock usually bears a like proportion. . When a portion of one or of both lower extremities is carried away by a gunshot, the higher towards the trunk the injury is inflicted, the greater may be expected to be the shock, independently of the loss of blood, panic, or other depressing circumstances. Not only the local, but also the constitutional injury is greater.

The following case is, however, well suited to illustrate the fact that shock may occasionally induce a speedily fatal result after an injury which in itself could hardly be regarded as one of extreme gravity. The late Professor De Chaumont, when serving during the Crimean war with the Rifle Brigade, was with a party of men in one of the ravines leading to Sebastopol, when two of them were struck by a gunshot from the great Redan. The first man struck was killed immediately. In the case of the second, who was by the side of the first, the shot passed along the upper arm, between the shoulder and elbow joints. The arm was near to the rocky side of the ravine at the time, but, so far as external evidence was concerned, there was nothing to show that it had been crushed by the shot against the rock. The integuments were sound, and as normal in appearance as if no projectile had passed near them. On examination, however, the shaft of the humerus was found shattered to pieces. The injury was followed immediately by symptoms of shock so extreme in degree that all attempts to rally the soldier from them failed, and the man died almost without power to speak a word from the moment the shot struck him. No internal organ had been damaged—this was ascertained by examination of the cavities of the body after death; nor was there any reason to believe that any part had been injured in addition to the arm already mentioned.

It seems probable that in uncomplicated flesh wounds by modern small-bore projectiles the symptom of shock will sometimes be entirely absent. This may be explained by the small area of bodily tissue traversed by one of these bullets, the extreme rapidity of its passage, and the trifling resistance encountered owing to its immense penetrative energy. Even when the speed of one of these narrow projectiles is much reduced, so long as only soft textures are involved in the injury, the wound may still

be unaccompanied by shock. The absence of shock was particularly recorded in the histories of two cases in which perforating flesh wounds had occurred from Lee-Metford bullets, one at a distance of 2500 yards, the other at about 100 yards. The man who was shot at the longer distance was wounded through the thigh. Another man was subsequently wounded at a similar distance from the spot where the rifle was fired, and also in the thigh, but this time by a Martini-Henry bullet. This man was aged, and was at once so overcome by shock, that two men, with whom he was in conversation at the time he was hit, had to support him as a prevention from falling, and to assist him into a neighbouring house. The age of the wounded man, together with the greater weight and volume of the Martini-Henry bullet, probably caused the different effect as regards the resulting shock.

Nature of shock.—The true nature of shock is a subject of much practical interest to military surgeons in relation to the treatment of some of the injuries with which it is frequently associated. On the views regarding it and its influence, decisions will often depend as to the propriety of performing an important surgical operation while any shock exists, or of delaying it until after the shock has subsided; or, supposing surgical interference to be regarded as admissible, notwithstanding the presence of a certain amount of shock, then as to the degree of shock which should contra-indicate it, and on the amount which would permit it to be put into practice with safety.

In the present state of knowledge it seems hardly possible to explain the nature of shock with precision, though the condition itself may be sufficiently described by its effects. When knowledge of the physiology of the nerves is still further advanced, when manifestations to which are given the names of nervous excitement, nervous exhaustion, and the like, are better understood, then, but not till then, shall we be able to say with accuracy on what conditions true shock depends. Some surgeons, in accounting for 'shock,' lay great stress on the concussion and direct mechanical effects on the whole body, including the nerve-centres, from the momentum of the shot; but this explanation will hardly prove satisfactory if it be generally applied. There can be no doubt that in some instances the effects of the stroke of a projectile, especially if it be a heavy one, and of the attendant percussion, are directly conveyed to the nervous centres, and so give rise to the occurrence of shock. But if this were sufficient as a general explanation, we should scarcely ever witness constitutional shock in any wounds from the narrow armoured projectiles. Their easy penetration, hardness, and consequent unchangeable form, great velocity, and little resistance that can be offered by bodily tissues to their progress through them, all conjoin to prevent local commotion at the seat of injury. Moreover, many instances

occur in which shock is strongly manifested, and in which there is abundant proof that no such general physical commotion can have taken place. In some of these cases, especially some in which lesions of nerves have occurred, the impression produced seems to be conveyed by the nerves to the nervous centres, and the shock that attends the injury to be due to reflex influence. That true shock, as distinguished from shock resulting from violent physical concussion, from mental depression after unusual excitement, or from the effects of panic on the part of the patient, is a phenomenon the essential relations of which are mainly connected with vital force, and with that endowment of the organisation only, may be judged from observation of cases of bullet wounds in which the injury inflicted is inevitably a fatal one. In such wounds the shock usually remains from the time of the first production of the fatal impression till life ceases. The practical experience of every army surgeon teaches him that when a bullet has entered the body, and the shock continues without any relief or evidence of reaction, internal organs essential to life have been involved in the injury.

Wounds causing death by shock.—It is very rare that shock of a fatal character occurs after gunshot wounds involving only one of the extremities, especially one of the upper extremities, as happened in a case previously related. In injuries involving a considerable extent of surface; in wounds penetrating the peritoneum; in cases of extensive destruction of bone, especially the femur by projectiles, fatal results are not unfrequently due to the effects of shock. Again, in all wounds, whenever the symptoms of shock persist and the depressed temperature continues, or when, after slight rallies, symptoms of collapse recur—in short, when reaction does not take place gradually and steadily within a few hours after the receipt of the injury, the condition of a patient must be regarded as very grave, and one in which a fatal termination may not improbably ensue. In the surgical history of the Crimean war there is an extract from the records of the general hospital in the British front, showing the causes of death in 100 fatal cases taken consecutively as they happened to stand in the admission book. Out of these fatal cases 22 are recorded to have died directly from shock, some within three or four hours, generally within twenty-four hours, after the wound was received. In only one of these cases was the injury confined to a primary wound of either the lower or upper extremity. This was a compound fracture of the femur from gunshot. In two other cases the thigh was also the region injured, the limb in one having been carried away by a gunshot; in the other, its lower half with the knee-joint having been destroyed by grape-shot; but in both of these amputation above the wounded part was performed, so that the superadded injury of the amputation has to be taken into account as regards the death from shock. Out of the 22 fatal cases, in 13

the abdomen had been penetrated; in 2 the pelvis; in 1 the chest; in 1 there was an extensive wound of the lower part of the face; in 3 the femur, with amputation in two instances; and 2 were extensive burns from explosion of gunpowder, one of these being complicated with fracture of the leg, forearm, and inferior maxilla. It is interesting to observe the preponderance of injuries to the abdomen in this list of deaths from shock—13 out of 22 cases.

Wounds from large projectiles lead to death from shock more frequently than those from small projectiles. The larger amount of surface subjected to injury by the missile, the greater resistance opposed to it, and the general commotion caused by it, sufficiently explain the fact of a more profound impression being made on the system by a heavy projectile than by one of small dimensions and comparatively little weight. Large missiles, moving at high rates of velocity, seem to produce analogous effects, as regards shock, to those which result from the severe crushing railroad injuries that occasionally occur in civil life. Out of the 22 deaths from shock in the 100 fatal cases, only 8 were caused by bullets, and in all of these the cavity of the abdomen had been penetrated by the projectile. In the remainder the injuries were from gun-shot, shell, or grape.

CHAPTER III

(C.) ON HÆMORRHAGE AS A PRIMARY SYMPTOM OF GUNSHOT INJURIES

Primary hæmorrhage in gunshot wounds.—Primary hæmorrhage is one of the local symptoms of gunshot wounds which varies very greatly in degree, not only according to the size and situation of the blood-vessels wounded, but also the manner in which the wounds are inflicted. In some gunshot wounds there is hardly any hæmorrhage of moment, simply a slow oozing of blood, slight in the aggregate; in some, no immediate flow of blood from the wound, although a vessel of considerable size has been divided; in others, in which vessels of large volume have been wounded, the hæmorrhage occurs so rapidly and to such an extent as of itself to cause speedy death.

Much difference of opinion has been expressed concerning the number of deaths which result after gunshot injuries from primary hæmorrhage on the field of action; and the question of the real proportion of fatal consequences from this cause to deaths from other causes in warfare is still an open one. There is no doubt about the fact that primary hæmorrhage from gunshot wounds, in which large arteries are opened, does not often come within the

observation of army surgeons. Out of 4434 wounds detailed in the British returns of the Crimean war, only 15 wounds of arteries, or 0·3 per cent., were registered; out of 87,822 wounds tabulated in the United States Circular No. 6 of 1865, only 44 gunshot wounds of arteries, or 0·05 per cent., were registered. But these enumerations give but little clue to the true proportion of wounds of large arteries, and the occurrence of primary hæmorrhage of a serious character on fields of battle. If hæmorrhage ensues from a wound of one of the main arteries at no great distance from the centre of circulation, it must lead to a rapidly fatal result, and we have no sufficient means of knowing the number of such cases which occur. Surgeons, after an action, are too much occupied with the urgent necessities of the living wounded to spare time for examining the wounds of the dead, in order to verify and establish the proportion in which such accidents have occurred. Thus many surgeons have described fatal primary hæmorrhage from gunshot wounds as exceedingly rare, simply because it has not been met with in their military experience; a statement which closer opportunities of observation might, perhaps, have led them to modify. M. Baudens took some pains to solve this question, and, referring to his service in Algeria, remarked he had often found by examination of the dead lying on fields of battle, that death had been due to primary hæmorrhage.

The nature of the projectile affects the occurrence of primary hæmorrhage.—An important distinction, in estimating the liability to primary hæmorrhage in gunshot wounds, arises from the kind of projectile by which a blood-vessel has been opened, whether by a large and heavy or a small and relatively light projectile. If an artery of medium size, in common with the parts adjoining, has been torn asunder by a gun-shot or by a large fragment of shell, the occurrence of hæmorrhage to such an extent as to imperil life undoubtedly is a rare event. The question does not arise when the occurrence of death may be explained by the mere extent or by the situation of the injury; but, omitting these cases from consideration, it may perhaps be said that death is scarcely ever caused by projectiles of great weight from simple primary hæmorrhage alone. If a vessel happen to be divided by a small and comparatively light projectile, a small fragment of shell, or a rifle bullet, there may or may not be fatal primary hæmorrhage. This will vary according to several circumstances. These circumstances are principally the size and situation of the artery; the manner in which the division is effected; the degree of check to the hæmorrhage from nervous depression and shock, and the amount of subsequent movement and disturbance. From the nature of things, hæmorrhage will constantly occur from a partially divided artery, and must always wear a more serious aspect than when it takes place from one completely divided.

Hence the dangerous outlook as regards hæmorrhage from the use of the new small-bore projectiles, which, as described elsewhere, are apt to cause lateral ex-sections of portions of the larger arteries when they are carried into collision with them, or even to pierce openings through them, leaving narrow lateral strips of the vessels entire.

Primary hæmorrhage in wounds by large projectiles.—Ordinarily, so far as the wounds by heavy projectiles are concerned, when large arteries have been divided, the primary hæmorrhage is comparatively small in quantity and of short duration—a sudden flow at the moment of injury, and no more. When a part of the body is carried away by a heavy shot or piece of shell, the divided arteries are generally observed to be in the same state as they are found to be when a limb is torn off by machinery. The lacerated ends of the middle and inner coats of the artery are retracted within the outer cellular coat; the calibre of the vessel is diminished and tapers to a point near the line of division; it has become plugged within by coagulum; and the cellulo-fibrous investing sheath, and the clot which combines with it, form on the outside an additional support and restraint against the escape of blood.[6] When large arteries are torn across, and hæmorrhage from them is thus naturally prevented, they are seldom withdrawn so far that their ends may not be seen protruding and pulsating among the mass of injured structures; yet, though the impulse may appear very powerful, further hæmorrhage is rarely met with from such wounds.

My eminent friend Baron Larrey has recorded an instructive case illustrative of this fact in his history of the siege of Antwerp. An artilleryman had his legs separated as he was standing near a gun which he was about to sponge, when he was struck in both thighs by a large fragment of a shell. It passed from behind forward. All the soft parts of the posterior and inner aspects of the middle third of each thigh were torn away, but neither femur was broken. The two femoral arteries were completely divided, and were seen in the middle of the torn flesh, but there was no flow of blood. The pulsation of each artery was very perceptible in the upper torn end down to three or four lines from its extremity, where on pressure it appeared to be plugged up. Surgeon-Major Forget, under whose care the case fell, feared to leave the arteries thus exposed without any artificial control, and applied a ligature to each; but there can be little doubt the ligatures were unnecessary—no hæmorrhage would have taken place. Baron Larrey mentions, that after the ligatures were applied he cut off the ends of the lacerated vessels, and on splitting them up, found just the same appearances as may be seen in an artery the bleeding of which has been stopped by torsion. Just before the final assault on the Redan, as some men of the regiment I was serving with were moving through the trenches, a gunshot passed along and carried away the right arms of three of them. There was

no hæmorrhage of account from any one of them at the time the wounds occurred. I have seen a leg taken off above the knee by a gunshot without any important loss of arterial blood; and my own experience would lead me to doubt if merely primary hæmorrhage ever does cause death when the injury consists of complete removal of a limb by gunshot.

The following case, the notes of which were given to me by the late Inspr. Genl. Taylor, C.B., in whose practice it occurred when he was surgeon of the 29th Regiment, is very interesting as regards this subject. At the battle of Ferozeshah, on December 21, 1845, Sergeant Reitchie was struck by a round shot in the left axilla. It divided the artery and smashed the adjoining structures, so that the arm only remained attached to the trunk by a portion of the deltoid muscle and the integuments covering it. The wounded sergeant lay on the field without attention of any kind that night, all the next day, and until the evening of the following day, the 23rd. On the 24th he was removed in a jolting hackery (a country cart without springs) to Ferozepore, and then amputation at the shoulder was performed, the flap being taken from the available soft parts. No hæmorrhage had taken place, and not a single ligature was required or used in the amputation, although two-thirds of the face of the stump consisted of the surface left by the passage of the shot. The wound healed favourably, and the sergeant was employed for many years afterwards in a staff situation. In the instance of the German soldier mentioned at p. 205, when the subject of shock was being considered, although his arm had been completely carried off by a large projectile at the shoulder, and although he rode in this condition all the way from Waterloo to Brussels without having received any surgical attention, no loss of blood of any account occurred.

Primary hæmorrhage in wounds by small projectiles.—When considering the subject of hæmorrhage from wounds caused by the spherical and larger kinds of cylindro-conoidal bullets, the fact, generally asserted, of the frequent escapes of arteries from division, even when the projectiles had seemed to travel directly in their course, forces itself upon the attention. It comparatively rarely happened, indeed, that surgeons saw any of the larger arteries cut across by musket bullets. The lax cellular connections of these vessels, their usually deep situations, the smallness of their diameters in comparison with their length, the elasticity as well as toughness of the tissues forming their coats, the fluidity of their contents, and, in consequence of all these conditions, the extreme readiness with which they were enabled to slip aside under the pressure of a bullet with a smooth and rounded surface, and moving at a rate of speed which can only be regarded as moderate by comparison with the velocities impressed upon modern rifle bullets, were circumstances which

favoured the escape of these important structures when they were subjected to imminent danger of injury from the passage of such a projectile in their direction. Repeated examples have occurred of musket bullets passing through parts of the body in the exact situations of important arteries without wounding them; so that they must have been pushed aside by the missiles, or they could not have escaped division. A young officer was under my care in the Crimea in whose case a bullet passed through the neck from side to side behind the larynx. From the course it took, the carotid arteries must have been pushed aside to have escaped injury. There is in the Museum at Netley a preparation of part of the femoral vessels taken from a soldier who was wounded in the thigh at Toulouse by a musket bullet. The projectile traversed the limb, and in doing so, notwithstanding its large diameter, opened the sheath of the vessels, and actually passed between the artery and the vein, without opening either vessel. Such was the pressure by the bullet upon the vessels, and such contusion and injury were inflicted upon them, that both the artery and vein became plugged by coagulum and obliterated. This case has been fully described by Mr. Guthrie, as well as a similar one in which the bullet passed between the popliteal artery and vein of a soldier without opening either vessel.[7] I have met with several examples of obliteration of vessels, indicated by the absence of pulsation below the site of injury, among men who had been invalided for wounds by rifle bullets. The obvious explanation in all these cases was that the trunks had been pushed aside and contused by the projectiles at the original seat of injury.

The position of a limb or artery when struck may prevent the escape, which might otherwise have taken place, of a blood-vessel from division. I had the opportunity of examining the fatal wound of Captain Hedley Vicars of the 97th Regiment, whose death led to so much interest in England. He had been struck by a bullet which had penetrated the right axilla and divided the axillary artery. His arm was stretched upwards in the act of waving his sword at the time he received his wound. The night was very dark, the distance to camp from the place where the sortie took place in which he was wounded was more than a mile and a half, and he sank from hæmorrhage while being carried up. Had the arm been dependent instead of elevated, and the axillary structures in a lax condition, the division of the vessel would probably have been averted, notwithstanding the bullet having penetrated the axilla.

In the course of the experiments which have been carried out on the Continent to test the wounding effects of the small-bore compound rifle bullets, particular observations have been made on the lesions of blood-vessels from their action. The results of such inquiries have been recorded by several surgeons; but perhaps the

most complete series of observations published are those by Professors Delorme, Chauvel, and Nimier, of the Val de Grâce at Paris. They have shown that partial wounds of blood-vessels are likely to be comparatively frequent in future wars after the new bullets have been brought into general use. Contusions of arteries, in consequence of their being thrust aside by passing bullets, will be less often met with than partial and complete sections of them. The experimenters named have met with such wounds of these vessels by narrow projectiles at all distances, even when their velocities have been considerably reduced. The partial divisions mainly consist of lateral sections and perforations of the vessels. The lateral openings result from a part of the substance of the vessel being scooped out and carried away. From a tenth to half or more of the cylinder may thus be completely removed. All three coats of the artery are cut away evenly, their edges remaining together in apposition without any inversion or eversion. How far similar wounds of vessels in the living human body will retain the same characters remains to be seen.

Complete perforations will occur when vessels of large size are wounded in which, under the momentary pressure to which they are subjected, the width of the vessels exceeds the transverse diameter of the projectiles. Drs. Chauvel and Nimier mention that they have observed such perforations in a proportion of one to nine in their trials, and that the two openings in the perforated vessel are clean, rounded, of the diameter of the projectile or slightly inferior, without any turning back in the interior, all three coats presenting openings with clean edges of equal sizes and limits. Occasionally, but very rarely, the openings are linear in form.

It is obvious that arterial wounds of this partial nature involve the most serious hæmorrhagic consequences. The means of safety, which might perchance be derived from spontaneous contraction and occlusion at the site of injury in a case of total division of the vessel, are wanting in these incomplete lesions, owing to the portions of the cylinder which remain intact, and in normal connection with the other parts of the vessel above and below.

Complete division of vessels also occasionally occurs from the stroke of the modern narrow projectiles, just as now and then happened with former rifle projectiles of larger diameters. In such instances, especially when the divided arteries are of moderate size, all the conditions exist which are favourable to the occurrence of retraction of the two divided ends, and for the usual concomitant means of stopping the hæmorrhage, at least as a temporary measure.

Collision of angular projectiles with blood-vessels.—Angular missiles, unlike the projectiles with smooth and rounded surfaces previously mentioned, rarely cross the paths of arteries without

causing contusion or laceration of their coats. Occasional instances have occurred of irregularly shaped fragments of shells passing in the course of arteries without contusing or tearing them open, so that the vessels must have yielded to the pressure and slipped aside in the same way as so often has happened with small-arm bullets. In the Crimea a shell fragment traversed the ham of a soldier of the 56th Regiment between the artery and the bone. The artery was thrust back out of the way and remained uninjured. A similar wound occurred in the case of a soldier of the 9th Regiment. In this instance the piece of shell scooped away some of the bone. This man recovered. In another instance a large shell fragment passed through the upper third of the thigh, between the artery and the bone, without injuring either, recovery following.[8] These, however, must be regarded as rare and exceptional cases. Experience in military surgery has sufficiently shown that fragments of shells, with linear and jagged edges, are likely, as might well be expected, to cause lacerated wounds of arteries, when the same vessels would probably have escaped division had they been brought into collision with bullets possessing smooth and convex surfaces. The remark applies equally to splinters of wood, fragments of stone, and all other missiles of the indirect kind with sharp and angular outlines.

Diagnosis of arterial lesions by bullets.—A doubt will occasionally exist whether an artery lying in the path of a bullet has been subjected to injury, either to a contusion or to actual division, especially when the course a projectile has taken is a long and deep one, and the external openings left by it are small, with thick soft tissues intervening between them and the deeper parts of the track. There can be no hesitation with respect to the diagnosis, when an artery has been wounded, and the communication between one of the external openings and the wounded vessel is direct. The interrupted pulsating flow, and the characteristic colour of the arterial blood which escapes, and more particularly, supposing that pressure can be applied on the vessel between the site of the wound and the centre of circulation, if the flow is controlled by it, are facts which sufficiently prove that the artery has been wounded. In other instances, the stoppage of pulsation in a vessel or its branches beyond the site of the wound, diminished temperature and impaired sensibility in the parts supplied by them under normal conditions, are almost indisputable indications that an arterial lesion has been inflicted. If, in addition to these signs, there are swelling and pain in the neighbourhood of the wound, the fact of blood having escaped and being diffused in the surrounding tissues from an open wound of the vessel is rendered obvious.

Wounds of large arterial trunks.—When any of the principal arterial trunks of the body are so brought into opposition with

small projectiles, whatever their form, that division does take place, hæmorrhage may be regarded as inevitable, and in the field it must in almost every instance be of a speedily fatal character. If it be such a vessel as the subclavian, the carotid, the femoral near the groin, and still more surely if it be one of the larger divisions within the body, the hæmorrhage will be so rapid and persistent that death will take place within a few minutes, or very nearly as quickly as if the aorta itself had been divided. The force of the arterial current is in excess of the means of resistance with which the divided vessel is endowed. Some extraordinary accidents have been recorded, in which even the aorta itself has been opened by bullets, and yet life has not been extinguished until hours, and even days, have elapsed; but these have occurred under such exceptional circumstances as by no means to militate against the general rule of their almost instant fatality. Probably there has never been a more extraordinary instance of such an event than one which is illustrated by a preparation in the Hunterian Museum [9] of a wound of the ascending aorta of a seaman, an inch or so above the valves, in which a spherical bullet is lodged. The presence of the bullet had served so far to check the hæmorrhage as to enable the man to live three days after he had been shot.

Wounds of vascular branches.—If, however, a branch vessel be wounded in action, the hæmorrhage may be only temporary in character, being checked by the usual natural means, and time may be given for surgical proceedings afterwards to effect its complete arrest, if the natural processes have not sufficed for the purpose. Individual cases will be modified by the force with which the projectile cleaves the vessel asunder, the shape of the part presented to the vessel, whether obtuse or with a flattened-out sharp edge, the nature of the parts behind the vessel, and other circumstances. As a general rule, the more nearly the mode of division approaches to that by incision, the more probable will be the occurrence of primary hæmorrhage; the more it approaches to division by crushing and rending, the more the probability of its occurrence will be reduced.

CHAPTER IV

(D.) OF THIRST AS A PRIMARY SYMPTOM OF GUNSHOT INJURIES

Thirst of wounded men.—Men wounded in battle generally suffer much from thirst. When the wounds have been attended by hæmorrhage, the thirst suffered is usually intense. In many instances, however, the urgent thirst of men lying wounded on fields of battle is in a great measure due to causes which have

preceded the infliction of their wounds. In summer campaigns, long and hurried marches under a hot sun on dusty roads without sufficient opportunities of quenching thirst on the way; constriction of the body by accoutrements while sustaining a heavy weight, causing rapid exhalation of fluid from the lungs and skin; broken sleep from night duties, inducing a state of semi-pyrexia; not unfrequently the issue of salt rations, with absence of succulent fruits or vegetables; excitement of the nervous system arising from the circumstances and dangers of approaching battle; and the still higher excitement in the conflict itself, stirring the passions, hurrying the circulation, increasing restlessness, and exalting the sensibility; these are circumstances which have not unfrequently acted as exciting causes, singly or combined, of the painful and intense thirst from which men wounded in action so generally suffer. The irritation and pain of many wounds, especially those in which bones have been fractured, help to intensify the feeling of thirst; and all wounds, if the men are left long enough on the ground for them to become inflamed, exaggerate the torture arising from this symptom when it remains unrelieved.

Aggravation of thirst caused by hæmorrhage.—Considering the circumstances which have just been named, and the increased urgency of the demand for a supply of fluid to the system induced by them, it can readily be understood how a wound attended by loss of blood, *i.e.*, by a direct abstraction of some of the fluids circulating in the vessels of the body, must vastly increase the trying want felt of water to quench thirst; and how it happens, when the drain from the system goes on through continued hæmorrhage, that the thirst of the dying soldier becomes a real agony.

Circumstances which modify the thirst of wounded men.—The extent to which thirst is excited among men suffering from gunshot wounds varies not only according as the exciting causes before mentioned vary, but is also affected by other circumstances. It may be moderated by the state of the atmosphere, as when it is damp, foggy and cold, for some of the conditions which excite thirst are then wanting. Personal peculiarities of constitution, and personal habits in respect to the amount and kinds of drink usually taken, will influence the extent to which the desire for fluid is experienced. But though the craving for water may vary in degree under different circumstances and in different individuals, the craving itself is still one of the most prevailing and urgent sources of suffering among wounded men on battle-fields; and no more charitable or merciful action can be performed than ministering to its relief when men are left lying helpless on the ground from want of opportunities for their removal; and no one of the miseries experienced by sufferers in this condition, on being relieved, conveys more intense satisfaction, or calls forth more marked manifestations of gratitude, than the relief of thirst.

CHAPTER V

(E.) LODGMENT OF PROJECTILES AND OTHER FOREIGN BODIES IN GUNSHOT WOUNDS

Lodgment of foreign bodies in general.—When a bullet, a fragment of shell, a piece of some indirect projectile, or any substance not belonging to the structures concerned, has entered or has been forced into a part of the body by a fire-arm and has not passed out again, whether its situation be known or unknown, the 'foreign body,' as it is termed, is usually described as having 'lodged.' Lodgment may occur in any structure, cavity, or viscus of the body. It is chiefly a result of low rate of speed in projectiles; but its occurrence is materially assisted by irregularities of outline, obtuse and flattened form, low amount of density, and other physical conditions peculiar to the substance which has entered. From these causes lodgment happens in more frequent proportion with such articles as are carried into the body by projectiles, and with projectiles of the indirect than with those of the direct kind. It has been already noticed that the frequent occurrence of this particular complication of gunshot injuries, lodgment, or the presence of metallic and other foreign bodies in the midst of tissues which in many instances have been severely contused and torn, is one feature among others which helps to separate them as a class from ordinary contused and lacerated wounds, as it equally does from incised and stabbing wounds.

Lodgment of bullets.—When the smooth-bore musket was in common use, lodgment of bullets, even when they had not struck bone, was of very frequent occurrence. This arose principally from the spherical bullet not having sufficient force, at the distances at which soldiers were commonly hit, to effect its passage directly through the parts opposed to it; but was also greatly due to its liability, owing to causes elsewhere explained, to be deflected from a direct line, and consequently to take a tortuous and prolonged course within the body. Hence a round ball might be prevented from making its exit by structures far away from those near its point of entrance. The conoidal rifle bullets of large volume, used at the time of the Crimean war, also frequently became lodged, but were not liable to lodge at distances as near to the point of fire as the former spherical projectiles were accustomed to lodge. Their greater force, shape, and mode of flight enabled them to pass through most parts of the body at such distances. But at greater distances from the fire-arm, when their velocity had become nearly expended, or materially lessened, by length of range, as happened before Sebastopol,

and, indeed, on all occasions when the combatants were far apart, their passage was greatly resisted by the opposing tissues, and their exit interrupted by the dense fascia and elastic skin, in the same way that the passage and exit of the former spherical projectiles were at shorter distances. The lodgment of any projectile may take place within short range when they have happened to strike, perhaps pass through, some object before entering the body, and by such means have become altered in form or broken; or when, after entering, they have been brought into collision with strong tendons or bones offering much resistance; or when, from peculiarity in the posture of the person wounded, the projectile, having had force enough to traverse one part of the body, afterwards enters another part of the body from which it has no longer force enough to enable it to escape. Altogether, it may be said that the fact of lodgment occurring has not been so much changed by the change to rifle projectiles, as the distance from the point of discharge at which under ordinary circumstances it is likely to occur. This distance will vary with the narrowness of the projectile, and with the degree in which its movements of translation and rotation are accelerated. For these reasons, instances of lodgment of the very narrow elongated rifle projectiles of the present time, armed as they are with immense penetrative energy, may be expected to become more rare than they have ever hitherto been in war, when such accidental complications are considered in proportion to the total number of wounds inflicted. Under occasional circumstances, when the troops engaged are at long distances apart, lodgment even of the ·303-inch bullets may frequently occur. Professor Delorme of Paris came to the conclusion, from trials instituted by him on the dead body with such narrow projectiles, that at distances short of 500 metres their lodgment will be scarcely ever met with in the soft tissues; that beyond 500 up to 1000 metres it will occur occasionally; that at 1500 metres and beyond that distance lodgment of them will happen very often. Other observers, however, do not admit that their lodgment is likely to occur so frequently at the distances mentioned.

Proportion in which lodgment of conoidal bullets has occurred.—It has not often happened that the proportion in which bullets have lodged among a given number of patients has been recorded, nor is it a matter of much practical importance for the information to be given, seeing that the proportion must vary continually with the distances at which the combatants are separated from each other. But as an example of experience on this head, in respect to comparatively modern projectiles, it may be mentioned that Professor Socin recorded the fact that out of 727 patients with bullet wounds treated in the hospital at Carlsruhe, half of whom had come direct from the battles of

Weissenburg and Spicheren, and the others from various engagements in France during the war of 1870–71, the bullets had lodged in 130 instances, or in about 18 per cent. of the number.[10]

Although the figures quoted show that the proportion in which the elongated bullets then became lodged was still a considerable one, there can hardly be any doubt about the proportion having been less than it was when the spherical obtuse-fronted bullets were in common use. The difference probably, on the whole, was not so important as it might at first be supposed to be, for the lodgment of other substances was and is still so constant a concomitant of gunshot wounds, as to make the subject of the lodgment of foreign bodies one which requires as much attention on the part of army surgeons as ever it did. It is a complication which influences questions of treatment, and one which often has a material bearing on the progress and ultimate results of gunshot injuries, particularly when the lodged substances are organic in nature.

The kinds of foreign bodies which are liable to lodge in gunshot wounds among soldiers on active service are very numerous.

Lodgment of small shell fragments.—When small fragments of iron from exploded shells strike and penetrate the body, they usually remain lodged among the tissues which have been wounded by them. They rarely escape by a wound of exit, as rifle bullets generally do. They frequently carry before them portions of the clothing covering the part wounded, and occasionally fragments of other substances on the persons of soldiers with which they have happened to come into collision. Any articles that happen to be near a shell at the time of bursting, or that its fragments strike against—stones and gravel on the ground, plaster from walls, woodwork, &c.—are liable to act as projectiles, and inflict wounds, almost as much as the shell fragments themselves. Among the patients brought into one of the ambulances during the siege of Paris was one with a long wound at the back of the thigh. It was found to contain a sharp-pointed piece of wood, which must have been torn away and projected by a shell that had burst near the man. He had escaped from being struck by a fragment of the shell itself. The irregular shapes of broken pieces of shell, their rugged surfaces and indented edges, cause them to be readily caught and retained by the muscular tissues into which they may have sunk. The lodgment of such fragments has always been of frequent occurrence in war, and may be expected to happen more frequently in future wars, and at greater distances from the focus of explosion, in consequence of the greater number of fragments into which shells are burst by the modern higher explosives, and of the greater force of impulsion impressed on them at starting. Although, however, the penetrative energy of such fragments will be increased by the higher rates of movement conferred on them

by the action of the new explosives, they must always be subject to variations in their power of penetration depending on the accidents of their forms and dimensions, the opposition they meet with from the coverings of the part of the body struck by them, and on the capacity of the particular bodily tissues penetrated to offer resistance to their onward movement.

Lodgment of foreign bodies derived from a soldier's person.—The variety of substances which projectiles are apt to carry into parts of the body wounded by them, and which are liable to become lodged also, are practically infinite. They include portions of woollen clothing and of cotton underclothing, often both combined; fragments of some of the articles comprising the field-kits of soldiers, and carried in their knapsacks; of other things, coins, keys, watches, &c., carried in their pockets; bits of leather from belts, shoes, pouches, &c.; articles carried in officers' pistol holsters; buttons, nails from boots, buckles, and other metallic substances belonging to soldiers' uniforms;[11] fragments of the weapons with which they are armed; splinters of their water canteens, and many other such articles. In short, fragments of anything soldiers happen to be wearing or carrying at the time of being hit, may be found lodging in the tracks of projectiles by which they have been wounded.

In addition to these foreign bodies from without, wounds are liable to be complicated by the lodgment of a variety of substances derived from the patient's body itself, which act as foreign bodies, and are indeed in all respects foreign bodies, so far as the new situation in which they are placed is concerned. A piece of integument, fragments of bone, teeth, shreds of contused tissues, detached from their normal connections and carried by missiles into new positions among wounded structures, are as much foreign bodies as splinters of wood and metal. They act quite as injuriously, from their nature, indeed often more injuriously, than inorganic foreign bodies under like circumstances. A splinter of bone carried from a broken rib, and lodging in a wound of a lung, adds immensely to the gravity of the case; a detached piece of muscle or tendon, driven into the midst of living tissues, may become a focus of irritation, and lead to troublesome, or even serious results.

Positions of lodged foreign bodies.—When a fragment of shell or other missile strikes a man point-blank, and tears away a piece of some pliable substance, such as cloth or linen, and both become lodged, they may be expected to be found lying together at the bottom of the wound: the piece of cloth like a cap in front, the missile behind. This is seen to happen both when a projectile stops in the cancellated end of a bone, and when its further progress is arrested in the midst of some of the soft tissues of the body. If the projectile fracture the shaft of a bone, the piece of cloth or linen accompanying it will be usually

caught by some of the fragments and be found lying among them. But if a missile strike the body slantingly, especially if its course within the body be a long one, then, as it passes on, it usually leaves any such woven substance behind in some part of its track. The gradual diminution in width of recent rifle projectiles has had a tendency to lessen the chances of lodgment of portions of clothing. But the reports of cases of wounds inflicted by the Chassepôt bullet sufficiently showed that the occurrence was still a very frequent one when that relatively narrow bullet was in use. The lodged fragments of cloth were less in size than they had been with former bullets, but the complication did not appear to be less common. Professor Socin observed lodgment of bits of shirt and uniform to be so common among the cases of gunshot wounds at Carlsruhe during the Franco-German war, both among the wounds with two openings as well as those with only one opening, that he was led to believe the quicker healing of wounds in those parts of the body which are usually uncovered by clothes to be partly due to their freedom from such textile fragments being carried into them. How frequently this complication will be met with in wounds by the new small-bore projectiles remains to be seen, but if only a few detached fibres of the soiled woollen or linen articles worn by soldiers on active service are carried into wounds, it may readily be understood they may give rise to disturbance of the healing process.

When the substance driven before a bullet is a hard one, like a button from the uniform, the missile, supposing it to be one which retains its original form, generally forces the substance to take a position on one side of the main track, while it passes on itself, and finds a more distant seat of lodgment, or makes its way out of the body altogether. The force of the projectile is partly expended in striking and driving in the piece of metal, but it still retains sufficient momentum to effect its escape or to reach a deeper or more distant place of lodgment. The figure, density, and other qualities of an elongated bullet are much more favourable for effecting a passage onwards, than are those of most of the substances liable to be driven into the body by it. Such subsidiary substances quickly lose the velocity impressed upon them, and are easily arrested by some of the surrounding tissues. It is of practical value to remember that, when bullets which have not become deformed, and hard substances driven in by them, remain lodged among the soft tissues of the body, they are only in exceptional cases found lying together in the same part of the wound, owing to the differences of form and of force, which, as a general rule, severally characterise such hard primary and secondary foreign bodies.

Such things as watches, knives, pencil-cases, seals, and other articles of irregular shapes and varied composition, which are

frequently carried in soldiers' pockets, are liable to be broken up into many fragments on being struck by bullets, and such fragments seriously complicate wounds, owing to their angular forms, and tendency to be driven in various directions. A case of gunshot wound in the thigh, related by Ravaton, has been often quoted, in which the healing was delayed by the fragments of a silver seal and a copper key which the patient had in his pocket at the time he was hit. The seal had a cornelian stone, which was divided into thirteen small fragments, while the silver part was broken into three pieces. The musket bullet by which the injury was inflicted was at once extracted, but it was not till three months afterwards that the last of the other foreign bodies was removed. The number of fragments into which the articles in the pocket were broken in this instance is far exceeded in one which occurred during the war of the rebellion in the United States.[12] A soldier was struck in the thigh by a conoidal bullet at Mine Run on November 27, 1863. The missile shattered two knives which were in the man's pocket, and carried the fragments together with itself, also broken up into pieces, into the man's thigh. In the account of the case it is stated that one hundred fragments of the knives and four of the bullet altogether were removed in the field hospital. Blood-poisoning led to the patient's death. Seven other fragments of brass, steel, and bone, including the iron back-spring and one brass side of one of the pocket-knives, were removed after death. Coins struck in a similar manner generally remain entire, though more or less bent and deformed. Serrier, quoting from M. Laroche,[13] refers to the case of a person who had twenty Napoleons in his pocket at the time he was wounded. The coins were struck by the bullet in its course, and were all driven into the cavity of the abdomen. They were found to be entire, but all more or less deformed. Dr. Hennen has described a case in which not only some coins were carried into an officer's thigh by a large projectile, but also the trouser-pocket of coarse linen in which the coins were contained. The whole were deeply imbedded in the vastus externus muscle. It was only after suppuration was established that these foreign bodies were discovered. Dr. Chenu, in his account of the Italian campaign of 1859, describes a severe case of bullet wound of the right groin with fracture of the ilium. After one month's treatment, two fragments of the bullet and a medal, and after three months a copper coin much bent by the projectile, were brought away. The wound then healed. He also relates that during the siege of Paris (1870–71) a fragment of shell detached from a soldier's tunic two brass buttons, both of which were projected violently into the left orbit, and destroyed the eye without injuring the eyelids. In another case a leaden bullet struck a button on the left side of a soldier's tunic, detached it together with a piece of cloth, fractured the sternum

and some ribs, and lodged beneath the wall of the chest on the right side. In this instance the bullet and button remained in contact and were extracted together; the bullet was impressed with the number of the regiment borne on the button. He also gives an instance of a knife being broken into fragments by a bullet during the siege, and carried into the thigh; another of a pair of scissors broken in a similar manner; a third of a nail from a boot lodging in the metatarso-phalangeal joint of the great toe.[14] Dr. Socin, in his surgical observations collected at Carlsruhe during the same war, refers to a case in which three French sous much bent, and two waistcoat buttons, which a wounded soldier had carried in his trouser-pocket, were extracted, at different times in the course of three months, from the man's thigh. He also describes a remarkable wound in which a bullet and button entered together. Singularly enough, in this instance, a Chassepôt bullet made a complete hole through the upper button of the soldier's uniform coat, but became fixed when half-way through the perforation. The leaden bullet penetrated with the brass button equatorially surrounding it, and the two were extracted, still in the same relation to each other, from a deep wound in the neck.[15] When hair, especially short hair like bristles, happens to be forced by a projectile into the soft tissues of the body, its lodgment may prove a source of great and long-continued irritation. Delorme has quoted the case of a mounted officer who was wounded in the knee. The bullet had previously passed through one of his pistol-holsters in which there was a brush.[16] A parcel of the bristles from this brush was carried into the wound by the bullet. During many years, notwithstanding the exit of the bullet, fresh abscesses constantly formed, and from each, on being opened, a bristle or bristles were evacuated. The officer was subjected to much suffering, and was prevented from walking. At last an abscess larger than any of the preceding abscesses formed, and the remainder of the lodged hair escaped with the pus.

Wounds on parts of the body uncovered by clothing have, as a general rule, the advantage of being free from the risk of lodgment of any of the substances which have just been mentioned. But they are not free from the lodgment of the natural coverings of the parts, such as the hair of the beard, whiskers, or moustache on the face, and these are often carried deeply into wounds, and, as already mentioned, the lodgment of hairs in the tissues may give rise to very prolonged irritation. Hair from the pubis has been driven into the bladder, and eventually has formed the nucleus of a vesical calculus. Neither are they of course free from the lodgment of extrinsic substances which may have been displaced by the projectile from the neighbourhood of the wounded part.

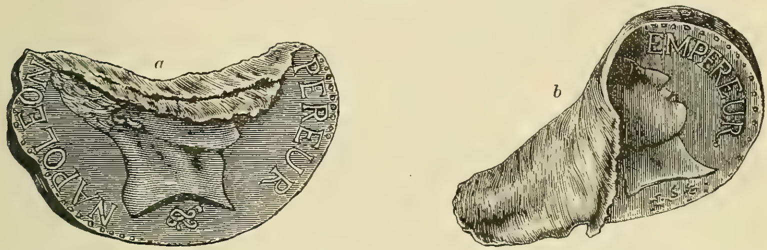
Lodgment of foreign bodies derived from surrounding

objects.—It may be readily understood that, just as substances derived from the person of the wounded soldier himself may become lodged, so others, derived from anything which may have happened to be near to him at the instant of his being hit, may become lodged also. Such articles may either enter independently as indirect projectiles, or may accompany the primary projectiles by which they have been detached from their original position. Sometimes parts of the bodies of wounded men are thus made to act as projectiles, and to inflict wounds on other men. Such fragments usually remain lodged in the wounds made by them. In a severe wound of the face which occurred to a soldier in the Crimea, the surgeon was at first puzzled by what appeared to be a strange displacement of a part of the upper jaw. After closer examination, and obtaining a clearer view by the removal of clot, it was found that the jaws of the wounded man were complete, but that a piece of the jaw of another man had been driven into the palate and impacted there. It had come from a soldier whose head had been shattered by a massive shot while standing by his side in the battery. Among other such cases which occurred during the Crimean war was one of a double tooth of a comrade being found imbedded in the globe of a wounded soldier's eye; and another where a portion of a comrade's skull was removed from between the eyelids of a soldier. Hennen has related a case in which, after amputation of the arm of an officer for gangrene supervening on a lacerated gunshot wound, the olecranon and part of the shaft of the ulna of another man were found imbedded in the tissues in front of the elbow. He has also recited the case of a sergeant from whom a deformed musket bullet, lodged under the temporal fascia, was removed. After its removal a substance which was supposed to be a small loose fragment of bone was felt, but on withdrawing it by a forceps it proved to be the body and crown of a bicuspid tooth. It had belonged to a soldier who had been standing nearly in front of the sergeant, and who had had nearly all the teeth on the left side of his lower maxilla carried away by the same bullet. Another soldier, who had had his arm carried off by a shot, and who had been lying among a heap of wounded in whose direction the enemy had kept up an incessant fire, after being removed to hospital was found to have several pieces of the bones of a cranium in a wound of his thigh.[17]

During the Crimean war an officer of the 97th Regiment came under the care of my friend the late Surgeon-Major Porter, with a long lacerated wound of the front of the thigh. He attributed it to a shell having exploded and caused him to wound himself with a ramrod that he was carrying in his hand. A fortnight afterwards Surgeon Porter extracted by incision from the back of the thigh, where a large abscess had formed, a long fragment

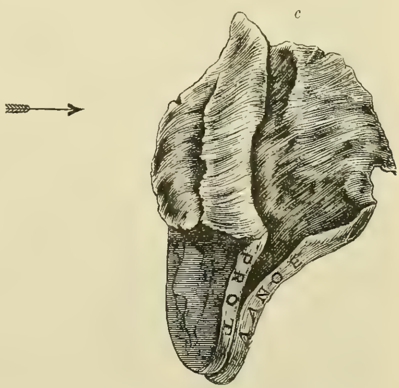
of the thigh bone of a man who had been killed by the shell in front of the officer. This splinter had caused the laceration, and not the ramrod, as the patient had supposed. When two or more men are wounded by the same missile, they are very likely to be struck in corresponding parts of the body. Thus I have known, as before mentioned, the right arms of three men standing behind each other carried off by the same shot; and on another occasion, the same bullet fracture the lower jaws of two men standing side

FIG. 40.



Pocket Coins defaced by a passing shot (see history in text).

by side. So, if a fragment of bone from one man lodges in the body of another man, for the reason just mentioned it may naturally be expected that the lodged fragment will have been detached from a corresponding region with that in which it becomes lodged. This may sometimes be the source of much puzzle to a surgeon, but the recollection of its probable occurrence will generally prevent a mistake in the diagnosis of such injuries. The same observation applies to articles of equipment and other things carried on the persons of soldiers. There was, until a few years ago, when some one stole it, presumably for the silver it contained, a curious relic in the Museum of the Army Medical Department at Netley, which afforded a further illustration of the facts just stated. Dr. Hennen extracted from the thigh of a Hanoverian soldier, on the third day after his admission into hospital, two five-franc pieces and a copper coin. The man declared he had had no



Sketch showing the relative positions of the two Coins after being struck.

money about him previously to the injury, nor even a trouser-pocket capable of containing any. The absence of a pocket in the man's uniform was proved to be correct. The coins must have been carried from the pocket of another soldier who had stood before him in the ranks and had been hit by the same grape-shot. The history of the case has been fully related by Dr. Hennen,[18] who presented the distorted silver coins to Sir J. M'Grigor for preservation in the Army Medical Museum, and he has added a curious account of the moral effect produced upon the soldiers in the hospital ward when they were shown the manner in which the Emperor's head on the coins had been crushed. As, however, they have disappeared, and I happen to possess some drawings of them which had been done for me by my friend Dr. Gillespie, I have inserted illustrations of them. The great force with which shot have struck substances opposed to them has been often manifested in a marked manner by the effects produced on metallic substances carried upon the persons of soldiers. In the present instance the two five-franc pieces seem to have been acted upon by the shot almost as if they had been so much wax. Part of the silver was completely carried away, and the exposed edges of the two coins where they were cut were pressed out, curved, and made to fit into one another exactly; and this was done while they were lying against a man's thigh!

Lodgment of scales of lead from bullets.—When a bullet of one of the old forms was broken into several fragments, one or more of them usually remained lodged. When musket bullets were in common use, a small superficial layer of the lead, like a portion of one of the concentric coats of an onion, was occasionally found to have become detached from it, and to have remained lodging at or near the site of injury. I was once applied to by a discharged soldier suffering from some troublesome granulations at the bottom of the left orbit. The globe of the eye had been destroyed nearly two years before by a musket bullet, shot from above, which, after traversing the orbit, had descended, and was excised from the right side of the neck. While examining the granulations at the bottom of the orbit with a probe, it came into contact with a hard substance which further examination showed to be lead. This proved to be a superficial layer stripped from the spherical bullet which had caused the original wound. It was about one-third of the sphere in dimensions, and retained the curved form of the bullet from which it had been detached. I have also removed a similar layer of lead from a deep wound in the neck. The fragment was lying close to the bullet from which it had become separated. Similar superficial sections have been occasionally separated from cylindro-conoidal bullets and become lodged. An officer of the 41st Regiment was wounded in the Crimea by a conoidal bullet which passed through the fore-

arm. Secondary hæmorrhage occurred on the eleventh day after amputation had been performed; the stump was then opened and examined, and a scale of the bullet about the size of a bent sixpence was found to have been the source of the hæmorrhage. A soldier of the 19th Regiment was wounded in the loin by a cylindro-conoidal bullet which was discharged per anum. Four years afterwards this man died from albuminuria in Guy's Hospital, and at the post-mortem examination a scale from the bullet was found fixed in the surface of the spleen.

Lodgment of projectiles of large size.—The projectiles and most of the substances hitherto mentioned as being liable to become lodged have been of moderate size. But very large fragments of shells occasionally bury themselves in wounds, and such heavy projectiles as grape-shot, and even some of the smaller kinds of gun-shot, have been known to become lodged in them. Fragments of shell, however, are the heavy projectiles which are most frequently found lodged in wounds. Dr. Grellois, in his account of the siege of Metz,[19] during the war of 1870–71, states that 'the number of fragments of shells, large and small, extracted from wounds in our ambulances was immense.'

Lodged foreign bodies often overlooked.—It has been shown by frequent experience that foreign bodies, when thus lodged, may remain for long periods, not only for days, but even for weeks, undiscovered, and this not only when they happen to have penetrated deeply among muscular tissues, or when they have travelled so circuitously and far from the aperture of entrance as not to be readily discoverable, but under circumstances when it might well be supposed the lodgment could not possibly escape notice. It becomes important, therefore, to put military surgeons on their guard respecting the occasional occurrence of such accidents. The fact of their happening may be accounted for in some of the several ways mentioned in the following paragraph.

Causes which contribute to foreign bodies in wounds being overlooked—Examples.—Sometimes the appearance of the seat of injury is liable to throw the surgeon off his guard. Penetrating fragments of shells, if projected edgeways, almost invariably lodge. In these cases the external appearance of the wound seldom indicates to the observer either the lodgment or the size of the body which has caused the injury. At an early period of the battle of the Alma, a piece of shell, which proved to be about 4 lbs. in weight, lodged in the buttock of a soldier of the 19th Regiment. It was very bulky, and to extract it I had to make an incision about as long again as the existing opening. In this instance the concave aspect of the fragment, evidently by its curvature and thickness a portion of a very large shell, had adapted itself to the parts lying beneath, while its convex surface so agreed with the natural roundness of the parts above, that it would have been impossible

to have arrived at a knowledge of its presence from any change in the external appearance of the parts. It was only by examination of the wound by the finger that information of the lodgment was obtained. Such fragments become very firmly impacted among the fibres of the tissues in which they lodge, and the effused blood fills up inequalities, and rounds off edges that might otherwise show themselves prominently, so that, without due care, their presence is not unlikely to be overlooked on first examination. The general symptoms that might indicate the presence of such a heavy substance are masked by the symptoms of the wound itself. The late Sir George Macleod of Glasgow has mentioned that he saw a case at Scutari in which a piece of shell weighing 3 lbs. was extracted from the hip of a man wounded at the Alma, which had been overlooked for a couple of months. Probably here also the shape of the fragment agreed with the natural contour of the part in which it was lodged.

The disappearance of the foreign substance in some of the natural cavities of the body, together with the absence of any prominent indications of its presence, owing to facilities for the escape of purulent discharges by some of the natural outlets, may lead the surgeon to remain unaware of its lodgment. In the well-known case of Lieutenant Fretz, of the Ceylon Rifles, the lodgment above the floor of the nose of the breech-piece and pin of the fire-arm which had inflicted the wound in his forehead, although weighing nearly 3 ounces, was not known till about a year after the injury, when the tapering end of the breech-piece and part of the pin made their way through the palate and protruded into the mouth.[20] In the Museum of Military Surgery at Netley there is the iron breech of a fowling-piece, weighing 4 ounces within a few grains, which had lodged in the face of a man, either in the nasal fossa or antrum, for twenty-three and a half years, when the fact of its lodgment was made known by its falling into the pharynx. The fowling-piece had burst, and when the patient was seen by Mr. Giraud, surgeon, of Faversham, there was an extensive wound over the right orbit, the orbital plate of the frontal bone was completely broken down, the eye and some brain were protruding at the seat of fracture, but no foreign body was discernible. The wound healed, after considerable sloughing of the brain and other mutilated parts, under simple treatment, without leaving any sinus or other indication of a foreign body having lodged in any part of the wound. After the lapse of the period mentioned, nearly twenty-four years, the subject of the wound, whilst in bed, was suddenly seized with a sense of suffocation, and at the same time felt that something had fallen into his throat. He started up, instinctively thrust his finger and thumb into his mouth, and then pulled out the breech-piece. As this case has not been hitherto published, I

have inserted some further particulars concerning it in the Appendix.[21] Dr. William Keith of Aberdeen removed the breech of a burst fowling-piece, weighing 2 ounces 5 drachms, and almost identical in shape with the one just mentioned, four months after the infliction of the original wound. 'It rested against the sphenoid bone in front of the sella tursica, with the screw bolt protruding laterally into the bottom of the left orbit.' Dr. Keith states that no suspicion had been awakened in the minds of the surgeons who had been previously in attendance on the case as to any foreign body having lodged in the wound. Dr. J. N. Fraser of Newfoundland extracted from the right maxillary antrum the breeching of a musket which had lodged there eight years without having been previously discovered or its lodgment suspected, although the patient had been under the care of several surgeons.[22]

During the Crimean war, at the capture of Yenikale, near Kertch, in the year 1855, a private of the 42nd Regiment was struck in the face by a bullet which had just passed through the head of another soldier of the regiment and had instantaneously killed him. The bullet struck the second soldier near the junction of the nasal bones with the os frontis, and penetrated in a direction toward the inner canthus of the left eye. Insensibility ensued immediately on the receipt of the injury, and continued up to the time of the man's removal to the hospital-ship. He made a good recovery, however, and subsequently went through the Indian Mutiny campaign without any known ill effects from his wound or impairment of general health. In June 1859, at Bareilly, he died from sunstroke, and on examination after death the bullet was found flattened and fixed to the perpendicular lamella of the ethmoid bone. There had been no ozæna, no defect of vision, and, indeed, nothing abnormal in the man's condition beyond a partial loss of the sense of smell on one side.[23] At Fort Pitt, Chatham, in the year 1855, Staff-Surgeon Parry extracted an iron shot, a little under 4 ounces in weight, which had lodged and was firmly wedged in the vomer of a soldier. The man had been wounded in the Crimea. A soldier of the 1st Royals was wounded in the Crimea by a grape-shot in the face. This projectile, which weighed 1 lb. 2 ounces, lodged at the back of the pharynx, and its place of lodgment escaped detection for three weeks.

Sometimes a surgeon may be diverted from searching for a foreign body by erroneous statements of the patient himself. There is in the Museum at Netley a preparation showing a large amount of new bone surrounding a united fracture of the upper third of the femur. In a hollow space within the bone there is a bullet. It can be seen through some small openings, and can be heard rolling in the cavity when the bone is shaken. The patient, who was wounded during the Indian Mutiny, declared positively

that his wound had been caused by a fragment of shell, and that he had seen the fragment glance off after it had struck him. It was only after the man's death, which occurred a year afterwards, that the fact of a bullet having lodged at the seat of injury became known. Dr. Hamilton of the United States has recorded the case of a soldier brought to hospital with a bullet wound through the calf of his leg. The man stated that the ball had gone 'clean through.' By means of Nelaton's probe, an iron shot, weighing 2 ounces, was discovered in the wound. Another man had a gunshot wound a little above the left ankle-joint. The man was told on the field that the bullet had glanced off after inflicting the wound, and was firm in his conviction that it had done so. Three months afterwards exploration by Nelaton's probe led to the detection of a Minié rifle bullet impacted in the tibia.[24]

Neglect of thorough exploration of wounds by surgeons, both at the first examination of them and subsequently, and an erroneous conviction on the part of patients that the pain and sense of weight arising from the presence of foreign bodies are due to the unavoidable effects of the wounds, can alone explain how substances so obvious to the touch, and of such sharp outlines, as are mentioned in the following instances, can have been not only undetected shortly after the injuries were inflicted, but have been allowed to remain lodged for prolonged periods although acting as sources of irritation to the parts among which they were lying. A strange feature, too, is that such oversights have not unfrequently been met with in cases in which the lodged substances have been in situations where it could scarcely be expected it would be possible for them to stay without being discovered.

A private of the 23rd Regiment was wounded at the Alma by a grape-shot, which carried away the left testis, entered the perinæum, and lodged. The ball was excised from the edge of the right natis on board the transport which took him to Scutari. The orifice of the urethra was grazed as the grape entered the scrotum, but the perinæal portion of the urethra escaped injury. He was two and a half months at Scutari, and then a fortnight at Malta. He left Malta in the *Cambria*, with the wound still unhealed, and was among those who were attacked by hospital gangrene in that vessel on the way to England. He was admitted into Fort Pitt on January 21, 1855, with the wound in the perinæum still open, but looking healthy. A fortnight afterwards Staff-Surgeon Parry, in consequence of matter having collected, incised the perinæum freely, and discovered a splinter of wood 4 inches in length, and subsequently two smaller splinters, all of which he removed. They were found to be fragments of the man's water canteen, which had been struck by the shot on its passage towards the scrotum. Another soldier was admitted into hospital at Chichester in 1856 with a narrow sinus near the left hip result-

ing from a gunshot wound. On inserting a probe, it passed deeply among the gluteal muscles and touched some rough body. An incision was made, and a piece of stone nearly 4 ounces in weight removed. This man had received his wound about twelve months previously, in one of the batteries before Sebastopol, and had been in several hospitals before reaching the depôt at Chichester.

In March 1871 a 20-pounder breech-loading Armstrong gun was being loaded at Bermuda with a shell, which exploded, and a sergeant, who was directing the charge of the gun, suffered several injuries in consequence. He escaped from being struck by any of the shell fragments, but received several wounds and contusions about the face and forehead from splinters of a wooden rammer with which the shell was being forced into its chamber at the time it exploded. He was sent as an invalid to Netley, on account of very defective sight; vision of the left eye having been destroyed by the entry of a small splinter of wood, and that of the right eye having been seriously impaired by inflammation consequent on contusion. At Netley, a small opening, from which some pus escaped, was observed in the under surface of the tongue near the frænum. On passing a probe, a foreign body was detected, and this, when extracted, proved to be a splinter of wood, in shape like an arrow-head. It was about an inch in length by a quarter of an inch in thickness, and was cleft into two parts behind. The point which had first entered was sharp; the rest of the piece of wood was split and much jagged. This foreign substance, strangely enough, had lodged in the tongue, in the situation mentioned, for twenty-two weeks undiscovered. It is preserved in the Museum of Military Surgery at Netley. It is not a little difficult to understand, considering the mobile and sensitive nature of the organ in which it found a settlement, how the sergeant himself had not been led to suspect, if not to ascertain, its presence. But even a piece of shell several ounces in weight has been known to lodge in the front part of the floor of an officer's mouth, and, accessible and obvious as this situation is, to remain undetected until the extension of swelling to neighbouring structures, threatening suffocation, led to further surgical advice being obtained.[25]

Special circumstances, such as the entry of two projectiles by the same opening, or by two openings so connected as to make them seem like one opening, and the fact of one missile being diverted into a different direction from the other, may readily throw a surgeon off his guard and cause him to fail in discovering them both. An officer of the 19th Regiment was struck in the back by two grape-shot during the assault of the Redan on the 8th September 1855. They both entered close together on one side of the dorsal spine. One of them lodged not far from the wound of entrance, and was readily found and extracted. The

other was at first supposed to have escaped, as it could not be felt about the back, but on further examination a swelling on the inner side of his right arm led to its detection. It was lying a little below the axilla, and from this situation I excised it. The thigh of a soldier was fractured in the Crimea, and a bullet extracted. There was only one opening, so that there was no reason for suspecting the presence of another projectile. The patient died at Scutari, and on examination after death a second bullet was found lodged at the seat of fracture.[26]

When the projectile which has lodged is of large size, and there is much distension of the neighbouring parts, this may be erroneously attributed to natural swelling of the injured and disfigured structures among which the foreign body is lying. In some instances it is probable that portions of the natural tissues are smashed to pulp and reduced in bulk by the pressure of the projectile on its first entry, so that any great amount of swelling is prevented, simply because the projectile occupies the place of the anatomical structures it has crushed or forced aside. In addition, the great pain of some wounds, together with the increase of it on movement of the parts, and the consequent urgent desire of the patients to be interfered with as little as possible, may tend to prevent surgeons from making that complete tactile examination which would otherwise prove the means of detecting the lodgment of foreign bodies in some instances. It seems extraordinary, however, that the mere weight of some lodged iron missiles should not at once have caused their presence to be ascertained.

In the Italian campaign of 1859 the lodgment of a gunshot weighing 2750 grammes (upwards of 6 lbs.), which had struck the shoulder and fractured the upper part of the humerus of General Auger of the artillery, was not discovered until the moment when amputation of the shoulder was being performed, and the knife came into contact with the metal shot. He was wounded at Solferino on the morning of June 24, and the operation was not performed until the 26th. The shot was found impacted between the subscapular fossa and ribs.[27]

Mr. Guthrie's experience during the Peninsular wars led him to record that 'it was by no means uncommon for such missiles as a grape-shot to lodge wholly unknown to the patient, and to be discovered by the surgeon at a subsequent period, when much time had been lost, and misery endured.' The same distinguished surgeon has described a case in which a ball weighing 8 lbs. was not discovered till the operation of amputating the thigh in which it had been lodged was being performed. Baron Larrey has recorded a similar case. A gunner had his femur fractured by a ball, which, according to the man's own description, had struck another artilleryman by his side after he himself had been

wounded by it. On his being brought to the hospital, no one doubted the accuracy of the statement that the shot had glanced off; but, upon amputation, the ball, weighing 5 lbs., was found in the hollow of the thigh towards the groin. The wound of entrance was on the outside of the thigh, and the ball had not only fractured, but had turned round the bone. Dr. Hennen explains the occurrence of large masses of metal lodging among muscles without betraying their hiding-places by their bulk, from the opening of entrance being so frequently smaller than the projectile; and he mentions that he had extracted a grape-shot through an orifice which, before incising it, was not a fourth part of the diameter of the ball. I have already referred to the same thing happening with lodged fragments of shell. A case related by M. Armand, one of the surgeons attached to the French Imperial Guard in the Crimea, confirms the occasional occurrence of a very small opening of entrance being left by a grape-shot. A soldier was brought to the ambulance, after the capture of the Mamelon Vert, with his left thigh wounded. An opening, such as might be made by a musket ball, was found on the outside of the limb. There was no second opening. A large swelling was detected in the popliteal space, without any external mark of injury, and without much pain on pressure. An incision was made, and an enormous grape-shot extracted. It had glanced round the femur without breaking it. M. Armand observed that the character of the wound alone would not have led one to suppose that any missile had lodged, and certainly no one would have suspected from its appearance that a projectile of the size of a grape-shot had been the cause of it. Dr. Chenu has mentioned two cases, which occurred during the Italian war of 1859 in which grape-shot were lodged near the ankle-joint. In one case the shot was retained one month, in the other two months.[28]

Were it not for repeated examples of such occurrences, it might be deemed almost impossible that foreign substances of such weight and size could remain concealed in the body, and sometimes in superficial parts of it, without the knowledge of patients or detection by surgeons.

Effects of lodged foreign bodies on the early stages of wounds.—The presence of foreign bodies in wounds in their early stages mostly gives rise to irritation, followed by efforts on the part of the living tissues to rid themselves of the offending substances. These results often materially interfere with the healing process. The degree of irritation set up generally varies according to the size, weight, condition of surface, and nature of the foreign bodies lodged, their freedom from dirt, the organ or part of the organ in which they are situated, together with the extent to which the effect of their presence is aggravated by movements within the body or by pressure from without. The state of health of the

patient also influences the effects of extraneous substances when lodged. But the lodgment of a projectile, even one of the least irritating kind, such as a small bullet with a smooth surface, may give rise to pain and other troublesome symptoms from the first in any part in the body, although the wound of entrance may gradually become healed over it. The protracted pain, disablement for military service, and other evils which may be induced from the lodgment even of a spherical musket bullet in a comparatively unimportant region of the body, are well shown in the instance of a soldier whose case I have described in detail in the volume of Army Medical Reports published in the year 1863. The man referred to was wounded in Burmah in the summer of 1856. The bullet lodged deeply among the gluteal muscles, but as it could not be felt by the surgeon, no effort was made to extract it. The wound after a time became healed. Subsequently he suffered pains, which were attributed to rheumatism. In May 1857 a deeply seated abscess formed in the neighbourhood of the wound, and the pus was evacuated by incision. Search was then made for the bullet, but it could not be found. The man was unable to proceed with his regiment on its removal to Bengal, and was detained in hospital at Rangoon. In April 1858 he was sent to England, and admitted as an invalid into the Fort Pitt Hospital at Chatham, halting in his walk, and occasionally suffering much pain in the inguinal region. A sinus still existed, leading deeply into the buttock. A suitable incision was now made, the bullet extracted, and the man was discharged to his depôt. In November 1861 this soldier was again invalided to Chatham, being found unfit for regimental duty, owing to restraint and difficulty in various movements of the limb on the wounded side. The adhesions and contractions resulting from the protracted inflammation, suppuration, and sinuses, due to the prolonged lodgment of the foreign body, sufficiently accounted for his disabilities. The consequences of the lodgment are occasionally rendered more serious when particular anatomical structures of the body are pressed upon by projectiles. Thus tetanus has sometimes appeared to be due to the irritation of nerves by foreign bodies which have been lying in contact with them, particularly when the nerves have been previously injured; and hæmorrhage has occurred through ulceration when they have exerted continued pressure upon blood-vessels. The subject will be further considered in the remarks upon the sequences of lodgment of foreign bodies in wounds in Section VII. of this work.

When the lodged foreign body is large and heavy, its effect upon the parts over which it is lying becomes increasingly deleterious in proportion to the time it remains unremoved. It directly adds to the injury which has been originally inflicted, by the mere influence of its bulk and weight, on the weakened

structures among which it is lying; and it interferes with the reparative processes which might otherwise be instituted by impeding the neighbouring circulation. The prolonged lodgment of the gunshot among the contused coverings of the chest in the case of General Auger, noticed at page 234, was partly the cause of the fatal gangrene which followed the amputation after that officer's injuries.

CHAPTER VI

(F.) BURNS FROM EXPLODED GUNPOWDER

Various sources of gunpowder burns.—An occasional primary complication of gunshot injuries is burning of the superficial tissues by the flame of exploded gunpowder. It has been chiefly met with in warfare on occasions of shell explosions, of injuries from fire-arms when the weapons have been discharged close to the persons concerned, of explosion of fougasses, or from the discharge of mines in siege operations and assaults. Burns from exploded gunpowder also not unfrequently occur from various accidental causes when troops are on active service. The ignition of cartridges, either in pouches or loose, and the explosion of stores of powder in cases, tumbrils, and powder magazines, occasionally furnish severe examples of such injuries. In civil life, burns from the explosion of gunpowder, from accidents in its manipulation or transport, and from careless dealing with it near flame, are of common occurrence, and the burning often gravely complicates other injuries inflicted at the same moment.

Characters of gunpowder burns.—The characters of the burns from exploded gunpowder are the same, whether they exist as a complication of injuries caused at the same time by solid projectiles, or whether the burns are simply accompanied with the blow, slight or otherwise, from the projected gas, the incandescent state of which gives rise to the burning.

The chief peculiarities of the burns which result from exploded gunpowder arise from the very short duration of time during which the body of the patient is exposed to the force of the fire, and from certain effects of the impulse of the gaseous projectile itself, by which the burns are usually complicated. In other respects – in their gravity according to the extent and depth of the surface burned, and the sites of the injuries; in the character of the inflammation by which they are succeeded; and in their results—they precisely resemble the burns which are met with in civil practice from the application of solid substances in a state of combustion to the surface of the body.

The flame or 'flash' of exploded gunpowder, the heat of which is intense, suddenly springs forth with great energy, but almost instantaneously disappears. Were it not so momentary, the high temperature caused by the deflagration of the powder would soon carbonise the parts of the body subjected to it and destroy life. If the powder which has been the source of it is confined within definite limits, as within a rifle or gun, the emitted flame may act locally over a limited space, according to the nature of the parts exposed to its influence, and the distance at which these parts happen to be from the opening whence the flame has darted forth; but if the exploded powder be comparatively free, as in the instance of a quantity of loose powder, or powder stored in a magazine, becoming ignited, the whole of the body may be at the same moment enveloped in an atmosphere of flame, though the surface fronting the direction from which the flame has been emitted will be most severely scorched by it. The extent of surface burned, and the severity of the burn, will vary according to the quantity of powder exploded, and the position of the patient in regard to the focus of explosion. The nearer to the source of the flash, the greater the force with which the flame is driven against the parts exposed to it, and the more intense its effect. Much also will depend on the kind and thickness of the coverings worn over the parts of the body exposed to the flash, whether they are of inflammable materials or otherwise, as well as on the accident of these coverings being either closely applied to the body, or being loose and open. In some instances the force of the emitted volume of incandescent gas is so applied as not only to char, but also to tear off some of the clothing. When this happens, the clothes are removed, and the parts of the body which were covered by them are subjected to the scorching effects of the flame, seemingly at the same instant. Sometimes the clothes are set on fire, and then add to the severity of the burn caused by the flash.

The burning of uncovered parts of the body usually penetrates the epidermis; but in most cases there is not time for it to pass deeper than the surface of the true skin below. The hair of the face is singed, and the corneal layers are rendered opaque, for, as as a rule, the flash is so instantaneous, there is not time for the eyelids to cover them. The exposure and scorching of the papillary layer of the derma cause the injury to be accompanied with great pain. When persons are exposed to the concentrated effects of the flash of explosions on a large scale, the burning may descend more deeply, and of itself entail speedily fatal consequences. In many of the respects just referred to, burns from the explosion of gunpowder greatly resemble the kinds of burns which are described as being produced by the ignition of coal-gas in mines. As a general rule, the extent of surface scorched, rather than the depth of structure destroyed, characterises the burns which

result from both causes alike; and, in both, the injured surface is liable to be penetrated and blackened, in the one case by smoke and particles of gunpowder, in the other by dust and particles of coal. There is another feature which sometimes increases the hazards of burns from exploded gunpowder. In some instances the action of the flame is not confined to the external parts of the body; the symptoms occasionally show that incandescent gas has passed down the throat and into the air-passages. Perhaps this may only occur when the act of inspiration happens to take place at the same instant as the emission of the flame. The fluids with which the lining surfaces of these internal organs are lubricated seem to act, however, to a great extent as a protection against the scorching influence of the heat which is thus suddenly applied, but as suddenly withdrawn; far more so than they do when the same surfaces are subjected to great heat through accidental inhalation of superheated steam.

Burns are not a usual concomitant of injuries from explosives of the nitro-glycerin class, as dynamite, forcite, and others. Their explosion is not attended by a luminous flame, and, however terrible the wounds caused by them may be, no evidence, either by sight or odour, is presented of the surfaces having been scorched. The surfaces of the wounded parts are not blackened, for the same reason that the flame is non-luminous, because no free carbonaceous matter is emitted as a result of the explosion. The same thing happens with explosives of the picric powder class, as bellite, melinite, and others. In an explosion of a melinite shell which took place at Belfort, in France, in 1887, Dr. Tachard, in describing the terrible mutilations caused by it, expressly states there was not the slightest trace of burning on any point, though the shell exploded close to the killed and wounded men.[29] The surfaces of the parts reached by the gases resulting from the explosion had a very intense bright yellow tinge, but this was thought to be quite independent of any action of heat or flame.

Concomitants of gunpowder burns.—Among the complications which attend these burns are the contusing effects of the force of the explosion upon the persons of the patients. The nature of the injuries which may result from exploded gas regarded as a projectile has already been discussed (see p. 167). In great explosions all those who are within the sphere of influence of the flame are usually too much injured by the explosive force to come under hospital treatment at all. If the body is not torn asunder, death is almost instantaneous from the combined effects of the general burning of its surface and of the shock of the concussion. When mutilation takes place, and limbs and other parts of bodies are blown to a distance from the centre of explosion, they are generally found scorched and blackened by the burning to which they were exposed at the moment of injury. The blackened con-

dition is not altogether due to charring. Even in comparatively slight burns from the explosion of gunpowder, the remains of the singed hair and the burned surface are generally blackened from being impregnated with fine carbon dust that has escaped combustion; and this appearance often gives to the burn, at the first glance, a more serious character than really belongs to it. Sometimes the burned parts emit a penetrating offensive odour like that of sulphuretted hydrogen, probably due to a certain amount of sulphide of potassium formed from the explosion of the powder being lodged in the charred animal structures. It also usually happens under such circumstances that unignited grains of gunpowder, particles of dirt, and other foreign substances are driven against the surface of the body with such force that many of them lodge in the wounded tissues, thus adding another complication to the burns, and still further increasing the blackened aspect of the injured parts.

CHAPTER VII

(G.) MULTIPLICITY OF WOUNDS

Frequency with which this complication occurs.—In war, from various causes, a gunshot wound is liable to be complicated by the occurrence of other wounds or injuries in the same individual, either inflicted simultaneously or within a short period of time after the original wound; and this complication often has a material bearing on the prognosis regarding the case of a wounded soldier, its treatment, and results. There are not sufficient data for forming an estimate regarding the frequency with which the co-existence of several wounds in the same individual occurs. The forms for statistical returns of wounds usually supplied in armies do not admit of such complications being readily tabulated. A soldier admitted into hospital with several wounds is put down in the numerical returns under the one which appears to be the gravest, and likely to detain him longest under treatment. It has always been regarded as an essential feature of military numerical returns that the number of patients admitted under hospital treatment should be correctly shown, and while the returns are confined to this basis, information on the number of wounds can no more be given than can the extent of surrounding injury and a variety of other circumstances by which the results of the wounds tabulated may be materially influenced. Such information could only be given numerically in returns specially prepared for the purpose.

Multiple wounds of internal organs.—It is obvious that when

bullets pass through the trunk, and especially when they traverse it in an oblique direction, many different visceral organs may be wounded by it in its passage. The same bullet may wound various organs in the cavity of the abdomen, and then, traversing the diaphragm, wound organs in the chest, or, passing from the chest, may afterwards wound a number of organs in the abdomen. Such cases are usually speedily fatal, but still exceptional instances occur in which life is preserved for a considerable time, and in which it only happens after death that the full extent of the multiplicity of the injuries which have been inflicted is made known. In the convoluted abdominal intestines the number of openings made by a single projectile may destroy all possible chance of life being preserved by any means. On July 31, 1855, Private P. B., of the 19th Regiment, imprudently left the advanced trench of the works in front of Sebastopol, and went over to the exposed side of the parapet to relieve his bowels. While stooping in the act of defæcation he was hit by a Russian bullet. It entered near the umbilicus, and passed out close to the sacrum. The poor fellow was brought up to the regimental hospital in camp during the night, and lingered till the evening, surviving the wound nineteen hours. On making an examination on the following day, I found that sixteen openings had been made in the small intestines by the bullet. The fact of such an unusual number of duplicatures of the intestine having been perforated, is probably explained by the position the man was in at the time he was shot, and the compression of the intestines by the diaphragm and abdominal muscles in the act in which he was engaged.[30]

It is not, however, so much multiplicity of wounds of internal organs from single bullets which is regarded in the present chapter, as the occurrence of several wounds in different parts of the body from distinct projectiles.

Influence of modern weapons on multiplication of wounds.— It has been generally believed that one effect of the introduction of breech-loading arms was to increase largely the number of patients with multiple wounds in warfare ; and it is not improbable that the belief was a well-founded one, especially with regard to occasions when small bodies of troops might be closely engaged with one another, owing to the rapidity with which these weapons can be discharged when compared with muzzle-loading arms. For a similar reason it is not unlikely the use of machine-guns has led to more frequent infliction of multiple wounds. Men exposed to their almost uninterrupted rain of projectiles can hardly escape from such complications. Dr. Frank, who saw and treated a large number of wounded after the battle of Sedan, and on many other occasions during the Franco-German war of 1870–71, afterwards informed me that he had seen no wounds from the French mitrailleuse. He thought this arose from the fact that a man hit

by one mitrailleuse bullet was almost sure to be hit by several others and probably killed on the spot.

Other sources of multiple wounds.—The complication of multiplicity of wounds among soldiers engaged in action with an enemy is, however, not a feature peculiar to modern warfare. It has always existed, although with less frequency, perhaps, in former campaigns; but its occurrence was noted in fire from lines of troops armed with the old smooth-bore muskets. The practice of 'double shotting,' which prevailed in some armies when muzzle-loading arms were in use, added to the liability of this complication.

Occasionally troops are inadvertently led into a position where they are exposed to a cross-fire, and examples of multiple wounds in individual soldiers then become frequent among them; or a soldier may accidentally expose himself to a cross-fire. A very remarkable instance of numerous wounds inflicted in this way without immediate fatal effects occurred during the United States war. The wounded man referred to, when admitted into hospital, presented twenty-six wounds of entrance and exit from rifle bullets. He was struck by fourteen bullets, one of which led to five separate wounds in the forearm and upper arm, while four of the bullets remained lodged in other parts. Altogether there were fifteen wounds of entrance, and eleven wounds of exit. Notwithstanding this large number of injuries, the patient survived twenty-eight days.[31]

Discharges of canister-shot, shrapnell, and grape, and indeed of all the larger projectiles combining in themselves a multitude of shot of minor size, have also been fertile sources of multiple wounds in individual soldiers; while, in the same way, shells, on being separated into a number of fragments by their bursting charges, have also often led, and must still lead, to similar results. The fact of men, already disabled by one wound, being again wounded while lying on the ground, or while making their own way or being carried to the rear, has been too often experienced; and the probability of its occurrence is a source of dreadful apprehension to all wounded men, and one which impels them urgently to seek speedy removal from the scene of conflict.

A patient was treated in one of the United States hospitals during the war of the rebellion who was suffering from the effects of four bullet wounds. His femur was fractured by the first shot; and while lying on the ground, disabled for movement, three other bullet wounds were inflicted upon him. He ultimately recovered, with the loss of one arm by amputation.[32] In most instances in which additional wounds are inflicted under such circumstances by gunshot, they lead to speedily fatal results on the field itself, as no doubt also happens in a large majority of the instances in which several wounds are simultaneously inflicted

in one and the same soldier. The wounds which caused death on the field were observed in 118 instances during the last New Zealand war, and it was recorded that more than one wound had been inflicted in many of these fatal cases. The exact number of wounds inflicted was not noted. The observations were only made for compiling a table of the regions of the body wounded in men directly killed in action, and the wound which was most likely to have caused death in each case was the one put down in the table.[33]

Recoveries after multiple gunshot wounds with other injuries.—The concurrence of multiple bullet wounds with injuries from other missiles, or with incised or stabbing wounds, is occasionally mentioned in the histories of particular cases of soldiers who have recovered, or who have survived and been invalided out of the army on account of them. I am not aware that they have been systematically collected in the history of any campaign. Dr. Chenu, in his history of the Italian campaign of 1859 (vol. ii. p. 294), gives the histories of a few remarkable cases, in which not only several bullet wounds, as many as five and even seven, occurred in the same soldier, but also some in which the patients, in addition, presented wounds from sabre cuts or bayonet or lance thrusts. In one case a soldier received four bullet wounds at Melignano, with two bayonet stabs, viz., a bullet wound of the left arm fracturing the ulna, another of the right side of the chest, a third through the left thigh, a fourth through the right thigh, and two bayonet stabs of the left thigh, and yet recovered. Another soldier recovered after a bullet wound of the left thigh, two others in the right thigh, a fourth bullet wound in the right side, and three bayonet stabs in the right shoulder, arm, and elbow. A third soldier survived after having had five bullet wounds, viz., one of the right shoulder fracturing the scapula, a second wound at the right axilla fracturing the upper part of the humerus, a third flesh wound of the lower part of the arm, a fourth wound of the left elbow, the bullet making its exit at the middle of the forearm, a fifth of the left hand fracturing the middle finger, and, in addition, a bayonet wound of the right forearm. Another soldier had two bullet wounds of the left leg, producing double fractures of the two bones, and five wounds in the right arm and right thigh from case-shot. An officer had a bullet wound of the left arm with fracture of the humerus, two others of the face and neck, a fourth of the left leg, and a fifth of the right thigh, with fracture of the femur, leading to amputation. Dr. Chenu mentions other instances of soldiers who had been pierced by several bullet wounds, and on whom other injuries had also been inflicted, and who yet made favourable recoveries.

Many examples unhappily occur in war of men, knocked over by gunshot wounds, being stabbed by lances and bayonets in the

fury of action. Some striking examples of this fact occurred during the Crimean war. Private J. Boxall, of the 4th Light Dragoons, was pensioned out of the service in April 1856, for a badly united fracture of the left femur caused by a gunshot wound at the action of Balaclava. He fell from his horse, and in the fall severely injured his right knee. While on the ground he received no less than twelve lance wounds. Private S. Weale, 38th Regiment, received a perforating bullet wound of the left hip, a shell wound of the same hip, and another of the head, and while on the ground received twelve bayonet wounds in various parts of the body. The official history of the Crimean war mentions the case of an officer who recovered after having been shot through the leg, and receiving seventeen bayonet stabs at the battle of Inkerman; and asserts that few men were bayonetted at that battle who had not already received one or more gunshot wounds which had partially or entirely disabled them.[34]

Multiple wounds from shell fragments.—Shells, when they happen to burst amid a group of men, or even near a single soldier when he is in the upright position, are particularly liable to inflict several severe wounds in the same individual. They not only cause injuries by their own fragments, but also by stones and other hard substances forced up at the moment of explosion. The instances of soldiers receiving more than one wound or injury at the same moment were particularly numerous in the trenches before Sebastopol, from the men being more or less confined in position, and from the effects of secondary projectiles derived from the parapets or surrounding objects. A remarkable instance of severe multiple wounds, which I saw under the care of my friend the late Mr. Rooke, was the following:—A private of the 77th Regiment, wounded by shell explosion, had an extensive part of the wall of the abdomen in the right hypogastric region removed, with laceration of the peritoneum and exposure of the intestines; a comminuted fracture of the crest and wing of the ilium; compound fracture of the right femur, and a fracture of both bones of the forearm, opening the wrist joint, together with extensive laceration of the soft parts in the neighbourhood of the broken bones. He was standing erect at the time he was struck. The forearm was amputated the second day after the injuries were received, and ultimately, after 133 days' treatment in the Crimea, this patient left for England.[35] Another terrible example of multiplicity of wounds in the Crimea was the following:—Lieutenant D., of the 3rd Buffs, was wounded on the 17th August 1855 by the fragments of an exploded shell. He had compound fracture of the thigh-bones on both sides, of both bones of the left leg, with great exposure and laceration of the muscular coverings, the right knee-joint opened, and simple, though comminuted, fracture of the right humerus. He also was standing up when wounded.

No other than palliative treatment was practicable with such numerous and grave injuries. They did not cause death, however, until seven weeks after they were inflicted.

But judging from the published histories of the results of accidental explosions of shells charged with some of the recently applied chemical explosives, multiplicity of wounds will be a complication of more general occurrence in future wars, and will entail greater difficulties for surgeons to contend against, than in any previous experience. The shells, which are usually made of cast-iron, are burst into such numerous fragments, and with such concentrated violence, by these high explosives, and the sharp and angular fragments are projected with such excessive force, that they frequently strike in a small shower, as it were, and penetrate the tissues very deeply. Some of the fragments are moderately large, but the majority are of small size, and some not bigger than peas, or even particles of sand. Thus, even though mortal wounds may be escaped from, and only the soft coverings of the body are penetrated, special risks may be expected from the mere number of wounds inflicted. The narrowness of the tracks, their sinuous character, their depth, the attrition of the tissues met by the hard and rugged projectiles in their path, must lead to impediments in the way of disinfection of the wounds, extraction of the lodged fragments, and the subsequent escape of discharges, and entail risks, in consequence, of various secondary complications.

Multiple amputations from multiple wounds.—The occurrence of multiple wounds, when two or more fractures of bones have resulted from them, is sometimes shown in the classified returns of campaigns under the head of double amputations. Dr. Chenu, in his history of the Crimean war, tabulates forty cases of double amputations in individual soldiers for fractures caused by various projectiles, the larger proportion being by burst shells and grape; and, in the English history, nine similar cases are tabulated between April 1855 and the end of the war. More than one bone may be fractured in the same limb, and fractures of bones in separate limbs may be caused by a single projectile. Although, under ordinary circumstances, the bone or bones of one division of a limb only are broken by the stroke of a projectile, it can readily be understood how a man having his forearm bent on his arm at the moment he is hit, may have all three bones of the upper extremity fractured by one and the same passing bullet; or how a bullet striking one thigh sideways with sufficient force and breaking the femur, may pass on and fracture the bone of the adjoining thigh almost at the same instant of time. Drs. Ashton and Spanton mention the case of an officer who was wounded at Sedan in 1870 through both arms and both legs, and had all four limbs amputated. He was riding, when a ball passed

through one of his legs, through the horse, and then through the other leg. At the same time a second bullet passed through both his arms. The horse was killed.[36] Under the circumstances of such multiple fractures, it may often happen that the treatment, suitable for either fracture alone, is found to be no longer applicable for the two combined. Amputation may be necessary in some such cases where conservation might otherwise have been attempted with propriety; and operative interference, such as amputation, may be rendered impracticable without the risk of entailing immediate fatal results in others, where it might have been performed with reasonable hope of a good result, if either one of the multiple wounds had occurred alone.

More precise information regarding this complication desirable in future wars.—The probability of an increase in the frequency of the occurrence of multiplicity of wounds, and the very important influence exerted by it in increasing mortality in action; or, where immediately fatal effects are escaped from, its influence on the treatment that has to be adopted in particular cases, and on the effect of treatment; the additional shock to the system of the patients in all instances; the greatly increased and prolonged suffering entailed on them; together with the aggravated risks as regards the final results in many cases; these and perhaps other considerations make it extremely desirable that more marked notice should be taken of this complication than it seems to have attracted hitherto—that not only the number of officers and men wounded, but also the number of the wounds inflicted on them, should be shown in future professional field returns, in case of the necessity for their use unhappily arising. The importance becomes greater in proportion as the destructive force of the projectiles employed, and the facilities for multiplying the number of projectiles discharged within short periods of time, are increased. There is good reason for fearing that the preponderance in the number of wounds and injuries inflicted over that of the number of soldiers hit will be found to be much larger in wars of the future than it has ever been hitherto, owing, as regards small-arm ammunition, to the enormously increased penetrative energy of the modern narrow rifle bullets, the larger supplies of them that will be at the disposal of the troops, and the great rapidity with which they will be able to be discharged on particular occasions by the introduction of the magazine system; and at the same time, as regards the larger forms of projectiles, to the greater number of pieces into which they will be broken up, and to the greatly increased force with which the fragments will be armed, in consequence of the employment of the new chemical explosives as materials for the bursting charges.

SECTION V

AIDS TO THE DIAGNOSIS OF PARTICULAR FEATURES AND COMPLICATIONS OF GUNSHOT INJURIES

THE characteristic appearances of bodily injuries from gunshot, and the primary symptoms and complications with which they are usually attended, have been described in preceding sections of the work. In the present section it is proposed to point out certain *extraneous* means by which a knowledge of some of the facts connected with them, especially the presence or absence of foreign bodies lodging in them, may frequently be obtained, or the judgment respecting these and other allied circumstances be assisted. The subject has lost some of its interest with respect to the present small-bore rifle bullets, from causes which will be explained, but still retains its importance as regards the spherical bullets of case and shrapnell, fragments of shells, and various secondary missiles of irregular forms.

The evidence which may occasionally be obtained from an inspection of the clothing or accoutrements worn by soldiers, of substances carried by them, or from the projectiles themselves, in case of there being an opportunity of observing them, are more particularly alluded to in these remarks.

CHAPTER I

AID TO DIAGNOSIS DERIVED FROM COVERINGS OF WOUNDED PARTS OF THE BODY

Information afforded by clothing.—The diagnosis in respect to some of the circumstances connected with gunshot wounds may often be materially assisted by inspection of the uniform, accoutrements, or underclothing of a soldier. The value of this examination is particularly shown in the determination of doubts as to whether portions of some of these articles have or have not lodged in a wound; it will also occasionally solve questions as to the nearness or distance of a shot, the direction which a

missile has had before entering, and, therefore, the direction it has probably taken after having penetrated the body, the probable site of its lodgment if it should not have passed out, and other similar matters which may require settlement. Evidence of the sort may appear trifling in itself, but nothing is really unimportant that helps to prevent unnecessary interference with a wound, or that serves to render the diagnosis of it more accurate and complete. In any case of gunshot wound, it is most important to determine as exactly as possible the course a missile has taken ; and any observations, however slight, which are capable of assisting a surgeon in acquiring this necessary information early are valuable.

Arrest of projectiles by clothing without or with wounds.— After an action, the protection which has been afforded in particular instances by clothes or other articles carried by soldiers has always formed a subject of remark. Bullets have been repeatedly found in the folds of rolled great-coats which have been worn across the shoulders or folded up on the back, in the padding of tunics, in the folds of handkerchiefs, in knapsacks, and other articles of accoutrement. I have elsewhere mentioned the case of a mounted officer who was saved from a wound of the thigh by the bullet being stopped in the leaves of a book which he was carrying in one of his pistol-holsters.

These coverings and articles, however, are not always so favourably situated, or, from other causes, especially the amount of velocity possessed by the projectile, they do not always present sufficient resistance to arrest its progress completely, though they may stop it sufficiently to prevent it from inflicting any but a comparatively superficial wound. So it occasionally happens that a projectile will have sufficient force to penetrate the body to a limited distance, at the same time carrying a portion of the wounded man's shirt before it, while, owing to the yielding nature of the material, it fails to tear a piece out of it. The missile will then lie, as it were, at the bottom of a prolongation or pouch of the shirt, like the finger of a glove ; and when the shirt is taken off, it will be brought away with it. The presence of the foreign body will of course be observed, if due care be taken to look for it shortly after the wound has been inflicted; but very often it is not possible to accomplish this, and in a field hospital, in the hurry of the moment, under the pressure of many patients urgently needing attention, it is very liable to slip away and escape without either the patient's or surgeon's knowledge. Or the projectile and its covering may not have entered so deeply as to be retained in the wound if the patient has been subjected to a variety of movements. This must have happened in the case of Captain M., who was wounded in a boat attack on Namtow, in the Canton river, by a large gingal bullet fired from the wall

of the town, on the 11th of August 1857. He died in the year 1876, near Netley, from the effects of stricture of the colon. During this long interval he had lived under a depressing conviction that the ball was lodged in his chest, and occasional attacks of pain, probably in reality connected with adhesions, led him to believe that it was lying near his heart. The surgeon, a very accomplished medical officer, who had attended him on the hospital-ship, was also fully persuaded that the bullet had remained in his chest. But the opportunity of an examination after death being afforded, a very careful search was made at Netley, and no bullet was found. The projectile had not even penetrated the chest, but it had struck the walls of the cavity with sufficient violence to fracture two ribs, and the sharp edge of one of them had grazed the lung superficially. Hæmothorax, and some other symptoms of wound of the lung had taken place as a consequence, and these indications had, not unreasonably under the circumstances, been misinterpreted. Thirty hours had elapsed before the wounded officer was received on the hospital-ship after his injury, and in the meantime the gingal ball had dropped away and been lost. Had the officer's shirt been examined in this instance, in all probability the true facts of the case would have been so far ascertained, that the patient would have been spared years of groundless anxiety. The fact of the shirt worn over a wounded part being untorn must of course be a sufficient proof that the wounding missile cannot have lodged in the man's body, even although it may not be found. In the same way a bullet may strike a soldier's boot and inflict a wound in the foot, without perforating the leather, or it may penetrate the leather, but fail to pass through the sock. In either case an inspection of these coverings will show that the bullet has not passed into the wound, and the forethought of making the examination may be the means of preventing an unnecessary exploration. It has happened that a bullet has passed through a boot on one side and through the foot, but has been prevented by the leather from passing out on the other side. In such a case the missile will of course be found in the boot if it be taken off with due precaution.

Mr. Guthrie relates that he saw an officer just after he had been wounded at the battle of Vimiera, into whose wound the shirt had gone with the ball, without any injury to the linen. On Mr. Guthrie 'pulling at the shirt, it came out from a depth of four inches a perfect *cul-de-sac*, having the ball at the bottom of it.' As the wound is described as 'having been received in the thigh,' it would be a portion of the free end of the shirt which had entered with the bullet, and this may explain its having been carried to so great a depth without being torn. Hennen refers to the wound of an officer who had several folds of a silk pocket-

handkerchief carried into the pectoral muscles by a bullet. On withdrawing the silk from the wound the bullet came away imbedded in its folds. The unfettered condition of the folds of the handkerchief doubtless assisted in causing the occurrence. Dr. Jobert saw a case in which a bullet, the force of which had been partly spent, failed to make a hole in the wounded man's shirt, but yet penetrated the cavity of the abdomen. On drawing the shirt out of the wound the bullet came too, and though a protrusion of intestine followed, it was reduced, and the patient quickly recovered. In this case the accident of the shirt not being rent open prevented the lodgment of the bullet in the peritoneal cavity, and saved the patient's life.[1]

It is evident from the examples above quoted that it is not sufficient for a surgeon to examine only the uniform clothing worn by a patient. A bullet may perforate a soldier's great-coat, tunic, or some of his accoutrements from which it has encountered more or less resistance, but yet it may fail to pass through the shirt, or some article of underclothing which is more free to yield to the pressure. The garment that happens to have been next to the skin of the part wounded is therefore that to which attention in all such cases should be particularly directed.

Evidence afforded when projectiles have traversed coverings of the body.—It generally happens, however, that when a missile has had force enough to penetrate the body, it will have previously made an opening in all the clothes or other articles covering the part of the body penetrated. Sometimes a glance at these openings will at once settle a question as to whether some portions of the substances overlying the wounded part have lodged in the wound. A piece punched completely out of a leathern belt, the loss of a button, a hole in a coat, vest, or shirt, which the flaps or torn edges when replaced toward the centre fail to fill up, will indicate the probability, almost the certainty, of the absent portions being contained in the wound. It has already been mentioned that when cylindro-conoidal rifle bullets were brought into use, they were found, almost equally with those of the old spherical shape, to carry such fragments before them on their first entrance into wounds, and that they would afterwards leave them behind in some part of their track, while they themselves would either escape or remain lodged at some distance from the place of entrance. It is to be expected that such occurrences will scarcely ever be brought to notice when the new narrow projectiles become the common sources of rifle wounds. Their little liability to lose their normal form, and the smallness of the openings left by them in clothing when they pursue a direct course, together with the fact that in many instances the texture of the portion of cloth removed is reduced to minute shreds by the force with which they are armed, cause such fragments, if lodged in wounds, to be

scarcely appreciable, and relatively of trifling importance from a surgical point of view. The effects are very different when the portions of clothing or other coverings are of considerable size, such as are often met with when the missiles concerned consist of fragments of shell, shrapnell shot, or some of the irregularly shaped secondary projectiles which frequently give rise to wounds in warfare.

It is a common occurrence when a fowling-piece has been discharged near to the body, to find a number of detached portions of the various articles comprising the clothing of the part wounded carried into the wound or wounds with the charge of shot. As their lodgment often seriously aggravates the symptoms resulting from the wound, it is well not only to determine the fact of the removal of these substances from the clothes, but also to ascertain the number of the fragments and their sizes. By this means, on some pieces of cloth or linen being extracted, it will be known whether the whole or only part of the lodged foreign substances have been got away. The observation of the torn clothing thus becomes a help in respect to some of the details of treatment. I have previously alluded to a case under my care in which a charge of shot was accidentally fired into the foot at very close distance. In this instance the pieces of the upper leather of the shoe and of the sock which were carried into the foot with the charge of shot were found on extraction to fill up exactly the holes left in the coverings mentioned. It was thus proved that no more fragments of them remained among the lacerated tissues of the foot.

Evidence afforded by clothing as to distance of discharge of fire-arms.—The fact that a weapon has been fired close to a person is frequently more obviously apparent from the state of the clothes than it is from the appearance of the wounded part which was covered by them. If the clothes be woollen, they are usually not only more extensively torn than they would be by a shot fired from a distance, but, if the charge consist of gunpowder, they are blackened by the smoke and particles of powder which they retain in their texture. If the muzzle of the gun happen to have been placed close enough for the flame of the ignited gunpowder to act upon them, they will also be scorched, and if the material be cotton or linen, may even be set on fire.

Dep.-Insp. Genl. Dr. Marshall has related the case of a malingerer in Ceylon who wished to escape from further service in the army. He was brought to hospital with a severe wound in the leg. The soldier, who had been on sentry, declared he had been shot by a Kandyan rebel from the adjoining jungle, and that he had fired at him in return; but the marks of gunpowder and the general state of the man's trouser proved that his musket had been discharged, not toward the jungle, but close to his own leg.[2]

Sizes and shapes of openings made by projectiles in clothing.—As a general rule, the size of the opening in articles of clothing covering a wounded part of the body should not be depended upon for indicating with precision the size of the projectile which has entered. When a bullet happens to penetrate at high speed in a direct line, the diameter of the hole in the cloth or linen covering the wounded part is usually rather smaller than that of the projectile or than that of the entrance opening of the wound itself, perhaps owing to the greater elasticity of the materials, and perhaps also to the fact of the bullet being clear of other things which would help to widen its track. It is occasionally larger when part of the texture adjoining that which was immediately opposite to the bullet has been torn away with it. Neither, as a general rule, should the shape of the opening be regarded as showing the form of the projectile. The form and dimensions of the opening will vary with the angle of incidence of the projectile, and also with the texture of the material through which it passes. A spherical bullet fired through broadcloth makes a round hole, but through an ordinary piece of canvas makes a square hole. This is owing to the different textural arrangements of the two substances. In the broadcloth the woollen fibres are closely mingled together, so as to form almost a uniformly even layer; in the coarse canvas the threads cross each other at right angles, and are readily disconnected. The crossing threads which remain entire in the canvas after the passage of a bullet, and which bound the portion carried away by it, necessarily form a square, while the fringed ends of the threads which have been stretched and then divided recede into the adjoining texture, especially after the canvas has been drawn open or put on the stretch. The opening made by a spherical bullet in a linen article of clothing on a wounded person, when a portion of its substance has been carried away, will sometimes present a rectangular appearance from the same reason, but at other times will be a torn hole of irregular outline, particularly if the texture be fine and close.

Openings of entrance and exit in clothing.—In any case, if a projectile make a wound of entrance and another of exit through a part of the body covered by clothes, especially if they are woollen, a careful examination of the clothes will scarcely ever fail to determine which has been the first, and which the second opening. Any missiles of sufficiently obtuse frontage, passing through a part of the body so covered, at a high rate of velocity, punches out, as it were, the part of the cloth which it first meets, and so makes a hole, through which it enters; but, in escaping again, it ordinarily forces its way out by simply tearing the texture of the clothes asunder. Part of the cloth is carried away from the first opening; while, as to the second, the torn edges, on being brought together, generally close it; or, if they do not do so completely, the part

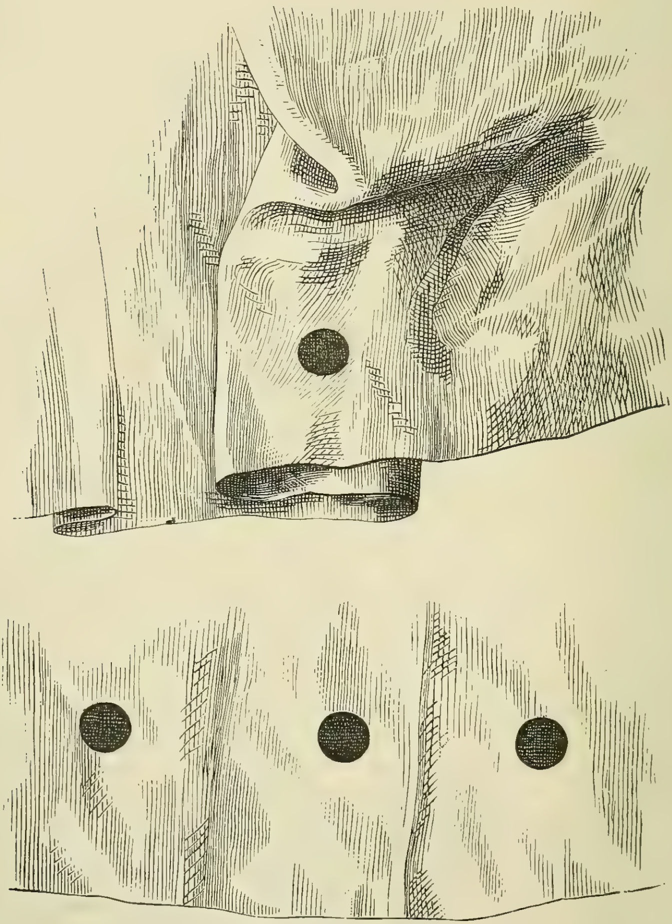
absent is usually less than that which has been abstracted at the first opening. Even the Lee-Metford 0·3-inch rifle bullet leaves behind it a small hole where it first entered, and from whence it has removed a certain amount of substance; while in the portion of the clothing through which it escaped there will be found a simple fissure or tear if the wound has been an uncomplicated one. The clothes will thus almost invariably give valuable evidence, should the question be raised as to which has been the wound of entrance and which the wound of exit of a projectile, as well as afford information on the probability of pieces of the materials having passed into a wound; and as the relative conditions of the two holes in the clothing cannot of themselves change, clothes, if undisturbed, are capable of giving their evidence on these points for an indefinite time, which is not the case with the wounds themselves.

It follows from what has been said that evidence may be obtained from observing a wounded man's clothes, which will sometimes be of great service in trials before criminal courts of law.

Evidence afforded by the number of openings made by projectiles in clothing.—If only one opening exist in each of the several articles of clothing over a gunshot wound, it is to be presumed that a single missile has passed through them and has entered the wound. But if more than one opening be found in each vestment, and the relative situations of these openings sufficiently show they are not openings of entrance and exit of one and the same projectile, a question may arise respecting the manner in which they have been produced. The following is an example:—Some years ago I saw a case of gunshot wound which was under the charge of my friend Mr. Sampson of Southampton, in which a careful examination of the patient's clothes settled a doubtful point of the kind mentioned, which must otherwise have remained in a state of uncertainty. A man committed a murder, and afterwards tried to destroy himself with a revolver pistol. The question arose whether two bullets or only one had been fired against himself. On taking off his clothes a slightly flattened pistol ball dropped on the ground. An examination of the patient's chest showed only one wound, viz., a small valvular opening between the cartilages of the third and fourth ribs, about half an inch to the left of the sternum. The termination of this wound could not be reached, nor could any proof of the lodgment of a foreign body in it, or elsewhere, be obtained. But, in addition to the foregoing wound, there was a slight contusion beneath the left nipple which might or might not have been made by a bullet. One bullet only appeared to have passed through the man's cloth coat and waistcoat. There was an opening firstly through the thick lappet, and secondly through the breast of the coat, as well as through the corresponding part of his waistcoat; and the direction of these openings led slantingly to the situation of the bruise beneath the

nipple. The ball, which dropped when the man was being undressed, on being examined under a simple lens of low power, was found to have some small fibres of cloth of a magenta colour pressed into its substance. This led to closer examination, and it was

Fig. 41.

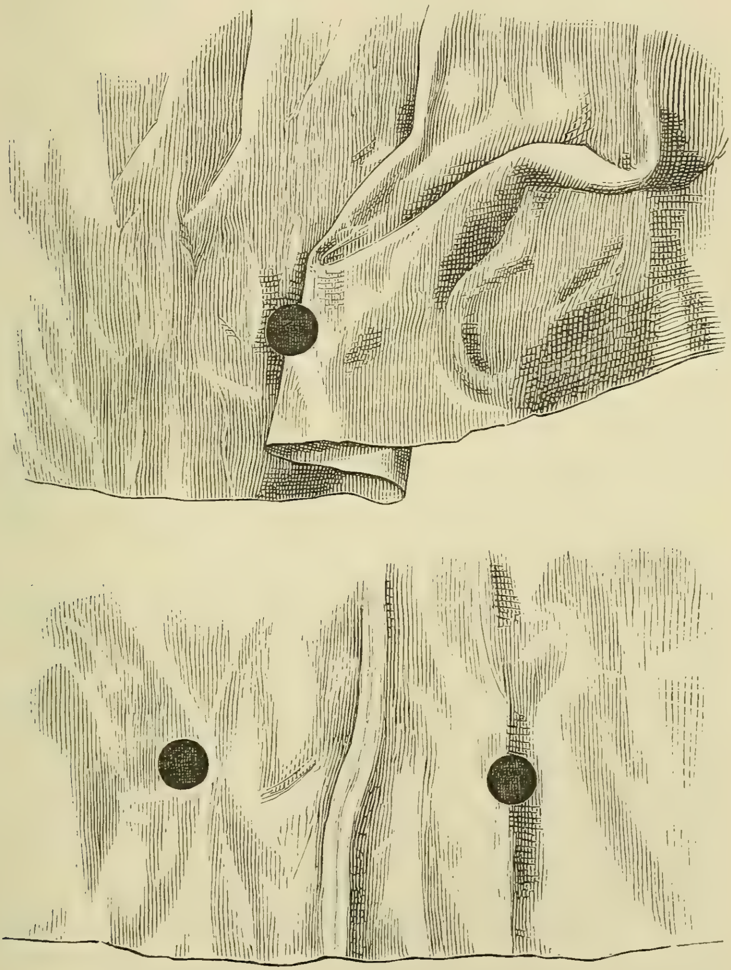


Sketch showing three openings from a bullet passing through a fold in a garment.

found that between the layers of cloth of the man's coat was some padding, part of which consisted of cloth of the same particular magenta colour, and also that this padding had been penetrated by the bullet. There could then be no longer any reasonable

doubt that the bullet which had passed through the man's coat and waistcoat was the one which was picked up, and that it was by this bullet the contusion below the nipple had been inflicted.

FIG. 42.



Sketch showing how the bullet may make only two openings in the same garment.

The man wore a flannel shirt, and beneath it a woollen under-vest. There was no hole through either of these near the bruised skin below the nipple. But above, nearly opposite to the spot at which

the wound was found in the chest-wall, a hole was found in the flannel shirt, and two holes, alike in size and less than an inch apart, in the woollen vest beneath. The hole through the flannel shirt, at a part uncovered by coat or waistcoat, was easily understood; but whence came the *two* holes in the woollen vest? For some time the existence of the two holes in the vest was sufficiently puzzling. It was thought that if the part of the woollen vest implicated had been doubled upon itself while on the man's chest, the bullet must have passed through three layers and have made three openings. Experiment showed, however, that if the duplicature were of such a character that the edge of the underdoubled part came exactly beneath the spot where the ball happened to enter in front, or *vice versâ*, then, under these circumstances, a portion of the united upper and under surface of the doubled edge beneath being carried away together, one hole in front and only one hole behind would be the result. The perforated substance would consequently exhibit two holes near to each other on being opened and laid flat. This was the explanation then arrived at. The man had fired two bullets against himself; one, after having traversed the thick folds of the padded cloth coat, had had its force so lessened as to be able only to effect a slight contusion; the other, passing through only the exposed flannel shirt and the under-vest, which had happened to be doubled in the manner described, had caused the open wound, and, having passed deeply, had lodged, whether at some spot in the chest-wall or within the cavity of the chest, observation at the time afforded no means of determining.

The illustrations figs. 41 and 42 show at a glance how a single projectile penetrating a fold in the body of a shirt may leave behind it either two or three holes in its substance according to the part of the fold it has happened to pass through.

Evidence afforded by the hair covering parts of the body.—Analogous with the information which may be occasionally afforded by examination of the artificial coverings of the body in respect to the course a projectile has taken, or to a question of its lodgment, is that which may now and then be derived from the natural covering, the hair. The hair on the surface of the body, like fibres of wool and feathers under corresponding circumstances, is remarkably little acted upon, or altered in condition or appearance, by the force of a projectile even at full speed. If struck by a bullet from a rifle, these substances are usually carried forwards for a certain distance in front of it, and then being released owing to the rotation of the projectile, or being caught and drawn aside by some of the surrounding tissues, they are left somewhere behind in its wake.

A very striking instance of the practical account to which a recollection of this circumstance may be turned is the following.

During the war of the rebellion in the United States a soldier was struck by a rifle bullet in the left temple. On the fourth day after the wound he came under the care of Dr. B. Howard. The patient was conscious, and gave his surgeon a succinct account of the injury. On examination by a probe, the bullet was found to have travelled beneath the skin obliquely across the forehead, until it had passed a little beyond its most prominent central part. At this point, to the right of the median line, was a small incised wound in which the bullet track terminated. This incision, the patient explained, had been made by a surgeon on the field, and through it, he stated, the bullet had been extracted. Above this small cut a slight depression could be felt on palpation in the bone. The case was regarded, however, as a flesh wound, but precautionary treatment was adopted. All went on well for a few days, when symptoms of compression showed themselves, and coma became almost complete. It was then determined to make a thorough examination of the part where the depression in the bone had been felt. On exposing this spot, the bone was found to be fractured, but the depression was slight, and there was no opening through which a foreign body might be supposed to have entered the cranium. At one spot, however, in the line of fissure, the end of *a single hair* was seen to be protruding from within the broken bone. Reasoning upon this circumstance, the conclusion was arrived at that the hair could not have been driven into the skull by itself; it must have been carried in by the bullet which caused the fracture, or by some other solid foreign body and left there. Some bone was then removed by trephining, and at a depth of about two inches from the surface a distorted Minié rifle bullet was discovered, and from this situation extracted. The patient eventually recovered, and subsequently resumed service as a cavalry soldier. Here all the evidence was opposed to the supposition of a bullet having penetrated the brain, with the exception of that afforded by this solitary hair. There was no visible hole in the skull, the tongue of bone which had been forced downwards by the bullet having sprung up again and closed the aperture; the patient's statement that the bullet had been removed by a passing surgeon was seemingly confirmed by the incision which had evidently been made by some one with a view to extract it; and it was not at all likely that a bullet entering near one of the temples, traversing the rounded forehead beneath the skin, and reaching its most prominent aspect, should then have fractured and penetrated the cranium. A single hair, however, decided that all this evidence was deceptive. It assured the surgeon that a solid foreign substance had entered the cranium, and led to the detection and removal of the bullet, which, had it remained lodged, must have rendered fruitless all other attempts to save the patient's life.[3]

CHAPTER II

AID TO DIAGNOSIS DERIVED FROM EXAMINATION OF PROJECTILES

When wounds have been inflicted by leaden projectiles and they have not been lost, a careful examination of them will occasionally afford evidence of diagnostic value in respect to the nature and complications of the wounds they have caused. The forms, composition, and other physical qualities of projectiles will also, not unfrequently, convey useful information when medico-legal inquiries are instituted regarding the gunshot wounds which occasionally occur in civil communities. It is always well, therefore, for surgeons under whose care such cases may happen to fall in civil practice, to take notice of the bullets, or portions of bullets, or other projectiles which have caused the wounds, whenever they have the opportunity of doing so, whether they may be extracted by surgical operation, or obtained by other means. The projectiles should be cautiously preserved, together with any other extraneous substances which may have been found with them in the wounds, in case questions should be asked on matters which they may serve to elucidate.

In future military practice observations of the kind are not likely to be attended with any practical advantage. The nature and qualities of the new compound projectiles are such that it can only be under the most exceptional circumstances they will be able to afford any useful information to surgeons by their examination, even if they should be recoverable for inspection, and circumstances admitted of attention being given to such matters. Now and then their condition may explain some features of wounds. As elsewhere shown, even these projectiles, notwithstanding the hardness of their envelopes, are subject to occasional deformation, and even to more or less complete separation of core and envelope occurring—circumstances which, when they occur, must materially affect the wounds inflicted by them.

Markings impressed upon soft and hardened leaden bullets.—It is remarkable what delicate marks will occasionally be impressed on the surfaces of leaden bullets by even comparatively soft objects with which they have happened to be brought into collision, and how distinctly these marks will be retained, notwithstanding the bullets subsequently pass through parts of the body, provided only that they are not violently impelled against bone during their passage.

Sometimes a leaden bullet in passing through clothes will take a perfect impression of their texture. Dr. Archer of the 98th Regiment gave me a small spherical bullet with a piece of

hempen cloth, which I have deposited in the Museum of Military Surgery at Netley, and in this instance the impression of the particular texture of the cloth is as strongly marked on the bullet as if it had been purposely engraved upon it. The bullet was fired from a matchlock musket during the Umbeyla campaign, and struck a native dresser on the outside of the thigh. It cut out a piece of his dhootie (an article of dress peculiar to men in India), carried it before it, and lodged beneath the skin on the inner aspect of the limb, whence Dr. Archer excised it. The cloth remained in close contact with the bullet at the time it was extracted, and as the projectile was very little altered in form, it had no doubt passed through the limb without having come into collision with the bone. The arrangement of the texture of the hempen cloth which it first met on striking the limb may be perfectly seen on the bullet.[4] The marks of the threads are flattened and widened in front where the pressure was most direct, and the meshes are enlarged towards the outer limits from the cloth having been stretched round the convexity of the bullet before the threads separated ; but the general texture of the cloth is so well marked that there could be no difficulty in identifying it.

But perhaps the most remarkable instance of a bullet retaining marks of a soft and yielding substance is the one which has been described at page 91, and is illustrated in fig. 34. The fact of any bullet striking unsupported canvas with such force as to lose shape and retain markings of the cloth, while failing to penetrate, seems remarkable ; but the occurrence in a hardened bullet gives the fact greater significance.

Substances imbedded in bullets.—Fibres of cloth, linen, and portions of hair are constantly impacted in the substance of leaden bullets which have traversed clothing. Some incrustation on a bullet removed from the thigh of a soldier at Netley, two years and a half after the date of the infliction of the wound, was examined with the aid of a magnifying lens. Abundance of cotton fibre was still observed in it. Some of the fibres were of a blue colour, some were white. It was then ascertained that the bullet, before striking the patient, had caught and carried away a piece of a cotton rug covering the bed on which he was lying at the time he was wounded. The colour of the rug was blue and white in alternate stripes.

When a leaden bullet strikes a bone in such a way as not to break it, yet with sufficient force and in such a direction as to denude it of its periosteum, it is usually flattened, and acquires an impression of the irregular surface of the bone, the bullet being rasped by it, as it were. These marks are generally well preserved, however circuitous its subsequent course through the soft tissues may be. Sometimes it breaks down some of the fine ridges or

other projecting irregularities which mark the outer surface of the bone, and minute débris will then remain firmly imbedded in the projectile. Such evidence, when it can be obtained, as it may be in case of a leaden bullet lodging and being extracted by the surgeon, is generally of diagnostic interest. The injury may be one that will shortly be repaired if the bone has not been struck; while, if struck, the case will be probably a protracted one, according to the amount of contusion to which the bone has been subjected, and the occurrence of some of its consequences, such as exfoliation, medullary inflammation, and other results much depending on the constitution and health of the patient. In the one case the injury may be a slight one, in the other of a serious nature; and the evidence afforded by examination of the bullet may in each case be the only certain clue to its nature at first obtainable by the surgeon.

The following incident will show that an observation of this nature may be of practical importance in influencing the steps of a surgical proceeding. My experienced friend Sir Anthony Home, who had been testing, at the time of the last war in New Zealand, Dr. Chisholm's plan of treatment for rapidly healing gunshot wounds, wrote to me from Wanganui an account of the results of his trial of it. Among other points he mentioned the following: 'On another occasion, when the case seemed just the one for another attempt, I had the scalpel in my hand, and had all but commenced the incision when some one brought me the bullet just then found. On examining it, I saw that it was scored by having been in contact with bone, and consequently that the case was one in which the procedure was inapplicable. I had examined the track of the ball through the calf of the leg most carefully throughout, and was satisfied that the bone had not been touched. The scored ball gave the truest information.'

When a bone struck by a leaden bullet has been completely fractured, or has had a splinter broken off, the projectile almost always retains some particles of the bone in its substance. The fragments are usually very small in size, though one or two are generally sufficiently distinct to be perfectly visible without the aid of a magnifying lens. Many examples of this fact may be seen in the Museum at Netley. Occasionally such fragments are sufficiently large and projecting to increase the injury done to other structures by the bullet in its passage. A bullet after having fractured a rib has been known to widen the area of laceration of a lung which it has subsequently traversed, owing to a fragment of bone of considerable size having become fixed in its substance. Ordinarily, however, the pieces of bone imbedded in leaden bullets have usually been of the size of particles of sand or small gravel. Particles of bone imbedded in this way may occasionally give evidence of the injury which has been inflicted, which may not be

obtainable by any other means. I had a soldier under my care in the Crimea who was shot in the loin. The bullet lodged, and all trace of it was lost. I took the precaution of arranging for the dejections to be isolated, and the bullet was subsequently recovered, being voided per rectum. It was a conoidal bullet, the apex had been turned back, and in it were impacted some minute particles of bone. This could only be from the bullet having come into collision with some part of the spine; but there was no paralysis, nor any other obvious symptoms of injury to the spinal cord. Three years afterwards this patient died in Guy's Hospital. At the post-mortem examination it was seen that the bullet, after passing through the spinal muscles on the right side, had entered the spinal column through the space between the third and fourth lumbar vertebræ, breaking the laminæ, had crossed upwards and towards the left side, and had finally left the canal between the second and third vertebræ. It had entered below the termination of the spinal cord, and had taken its course outside the membranes of the cord.[5]

Bullets that strike hard substances before entering the body will frequently retain particles of the objects with which they have been brought into collision, and these occurrences may occasionally be turned to diagnostic account. An officer, who was for some time under my observation, had received a severe and extensive wound near the knee-joint from a rifle bullet while struggling on the ground with a wounded bear in India. Numerous fragments of the bullet were extracted during the progress of the case. It was not understood how the bullet could have struck with force enough to be so completely broken up, and yet only the surface of one of the condyles of the femur have been injured by the missile, until a piece of silex imbedded in one of the lead fragments was noticed. It was then obvious that the bullet had not hit the bone with direct force, but had first struck something on the ground close to the part where the limb was wounded. The bullet had been broken into pieces against a stone or sand just outside the knee, and it was these fragments which had penetrated and inflicted the injury.

Thus circumstances connected with gunshot wounds may be frequently ascertained, many years after their occurrence, by close examination of leaden bullets, owing to the facility with which particles of objects struck by them become imbedded and fixed in their substance, and the length of time they remain there unchanged. It is seldom, indeed, that the fact of a leaden bullet having struck bone, wood, sand, glass, woollen cloth, hair, cotton, or linen may not be proved, years afterwards, by minute examination of the projectile. The mixed lead and tin projectiles are not so hardened as to prevent them also from being able to afford similar evidence under corresponding circumstances,

though it is not to be expected they can do so with the same frequency as bullets made of simple lead; with armoured bullets such aids to diagnosis will probably be altogether absent.

Evidence afforded by weight.—The weights of the rifle and pistol bullets used by the armies of civilised nations are mostly of fixed standards, and can generally be ascertained without much difficulty. This knowledge may also be occasionally turned to use in hospital practice. It has already been mentioned that leaden bullets, after entering the body, used frequently to have small pieces detached from them. By weighing an escaped or extracted bullet, it could be determined whether any portion of it was missing. In case a deficiency in weight was detected, it might well be suspected that a portion had been left behind. On such a hint a detached fragment was sometimes looked for and found; whereas without it its lodgment might have remained unsuspected, and various ill consequences have resulted. A scale of lead from a bullet may produce irritation and pain for years until it is removed, may give rise to secondary hæmorrhage, and, as in a case elsewhere mentioned, may cause amputation to be resorted to. For these reasons it is always a source of satisfaction after the extraction of a distorted bullet, or of one or more fragments of a divided bullet, to ascertain with certainty, in any case of doubt, that the whole projectile has been removed.

When a deficiency in the weight of an extracted projectile is noted, it need hardly be said that before taking any active measures to search after the missing portion, the surgeon should satisfy himself that the entire bullet had originally entered the wound. The history and circumstances of a case on being sifted will generally afford sufficient indications on this point. A soldier was admitted into Fort Pitt Hospital who had been wounded some weeks before by an Enfield rifle bullet while at target practice. The bullet had lodged at the time of the accident, and had not been removed before his admission. It had entered the right cheek, and had passed downwards, fracturing the lower jaw in its passage. On examination, a foreign body was detected as it lay imbedded in some swollen soft tissues below the maxilla. From this spot two flattened fragments of the bullet were removed in succession, and no more could be discovered. The two fragments were found to weigh only 280 grains, while the bullet, if complete, would have weighed 530 grains. The first opinion formed, therefore, was that more of the lead was still lodged, but it was ascertained that the bullet, before striking the patient under examination, had previously passed through the face of another soldier, whose jaw it had also fractured. The bullet had been broken when brought into contact with the maxillary bone of the first soldier. Part of it had been deflected, and had lodged in the nape of his neck, whence it had been

excised, while the rest of it had passed on, and had lodged in the face of the second soldier. Had no care been taken to obtain this history, further search would have been made for the purpose of trying to discover the missing portion ; as it was, it was evident that none was required, and the wound went through its course without further trouble. It is always well for surgeons to ascertain, as completely as circumstances will allow, all the facts of a case, and also to obtain the confidence of a patient, before resorting to surgical interference. A surgeon in the Crimea, after long exploration of the gunshot wound of an officer, happening to remark that he must give up further search for the bullet, was addressed with much bitterness by the patient in the following terms: 'Is that what you have been doing all this time? why didn't you ask me about it? I have got the bullet in my pocket.' It had been extracted from the wound before the officer was brought from the trenches up to camp.

It is not, of course, supposed that the minutiæ of examination described in detail in this chapter are applicable to the circumstances of military practice in the field. As regards the new rifle projectiles, observations of the kind, if they could be carried out, would, as a rule, be of no advantage. But leaden projectiles are not yet excluded from all the troops forming parts of civilised armies, and many years are likely to pass before they disappear from the weapons of some of the enemies with which British soldiers frequently have to deal. The attention has been called to the several points described, because a knowledge of them may still be occasionally useful when applied on suitable occasions. In the field the pressure is too great for elaborate attention to be given to individual cases ; but even in field hospitals a rapid glance at the coverings which have been taken from off a wounded part, or at a projectile which has been extracted from a wound, will not cause any appreciable delay, and will sometimes prove serviceable in the interest of a patient. In the accidental or intentional wounds inflicted in civil communities, the attention of a surgeon should always be given to such details; it is not possible to determine beforehand how important evidence so obtained may afterwards prove to be.

SECTION VI

OCCASIONAL COMPLICATIONS OF GUNSHOT INJURIES

General remarks.—An account of certain accidental complications to which gunshot injuries have been particularly liable in time of war is given in the present section. These accidents, which may or may not supervene on gunshot injuries according to variations in the circumstances under which they occur and are treated, are very diversified in kind and in degree. They are derived from widely different causes, and the modes in which they are manifested are equally dissimilar. They may in some instances be apparently due to certain phases of the original injuries, such as their nature and extent, or primary complications; in others, to peculiarities of individual constitution or previous habits of life; but, more generally, are attributable to special external conditions, especially to unhygienic surroundings, to which the patients have been subjected either before or subsequently to the receipt of their injuries.

The advances made in the sciences of pathology and hygiene have been so vast during the last few years, and acquaintance with them so diffused, that there is every reason for hoping the accidental complications described in this section may never again be witnessed in the fatal epidemic forms in which they occasionally occurred in the early campaigns of the present century. But that they will not occur when troops are in the field, though in a less general way than formerly, is more than can be anticipated. When war is in the ascendant everything has to yield to the main purpose in view—to conquer in order not to be conquered. The usual order of things, even sanitary precautions and rules, have to be subordinated to the achievement of this object. And on whichever army defeat may fall, when its soldiers are subjected to constant movement, excessive fatigue, depression, want, overcrowding, or when troops are cooped up in besieged places, exposed to pernicious exhalations from the ground, and to air loaded with impurities, then some of these complications will seize on the wounds prone to receive them, and the old results be repeated. The knowledge of medical officers as to the means of prevention and the control of such complications is too often of

small avail under the circumstances named, for it can only very partially be practically applied; but still no efforts should be spared to neutralise the conditions which favour their occurrence, as well to mitigate the evils which exist, as to prevent as far as possible their spread, the tendency to which is constantly increasing in an increasing ratio so long as their activity is not subdued, or at least materially weakened.

The complications under review may be conveniently divided into two categories—local and general. In the first category the complication is local in origin, and the constitution of the patient, when disturbed by it, is secondarily so; in the second, although the exciting cause may have been originally local, the affection is chiefly a constitutional one, and when local appearances are presented, they are manifestations of the general poisoned condition of which the patient has become the subject, and not simply indications of mischief confined to or extending from the particular locality in which they are seen. In the first category may be classed—inordinate inflammation at the seat of injury; gangrene; and secondary hæmorrhage. In the second category may be placed—hospital gangrene; pyæmia; tetanus; erysipelas; and traumatic delirium. An offensive complication which has frequently defied prevention in tropical climates, the development of maggots in gunshot wounds, will also be briefly adverted to.

It is not the purpose of the remarks in the succeeding chapters to enlarge on the phenomena characterising the special complications just named, or to attempt to describe the microscopic organisms associated with them, by which it has been sufficiently proved that some of them may be propagated, and in which most surgeons now believe their existence originates and is maintained; this information must be sought for in pathological works specially devoted to such subjects. It is chiefly the aspects under which they have been observed from time to time in military practice to which it is intended to call attention in this work.

CHAPTER I

INFLAMMATION ATTENDING GUNSHOT WOUNDS

Inflammatory action after gunshot wounds.—Until a few years ago it was accepted as a rule that every gunshot wound, the most trivial as well as the most severe and complicated, would be naturally followed by the usual indications of inflammatory action—not merely the restricted local inflammation which accompanies the reparative process after all wounds, but inflammation of a more severe

and extended character, with a certain amount of general febrile disturbance. In trifling wounds the local inflammation might be very slight, and no fever noticeable; while in most gunshot wounds of a simple uncomplicated description through soft tissues, only occurring in healthy subjects, the local inflammatory action and general fever would be only moderate in degree. But in all severe gunshot wounds, whether rendered severe by their dimensions, directions, or special complications, high local inflammatory action, constitutional irritation, separation of sloughs, copious suppuration, and various other sequences of the inflammation were regarded as matters of course. These views are now materially modified.

Some years ago I had the opportunity of observing a contused and complicated gunshot wound from a charge of small shot go through all the stages of repair to complete cicatrisation, under strictly antiseptic treatment applied in every detail from the commencement. This wound became healed without any local pain or tenderness, heat or redness, with no rise of temperature beyond the first day after the injury, and although by second intention, yet with scarcely any discharges—in short, without any evidences of action that could properly be styled 'inflammatory.' I saw, therefore, that inflammation could no longer be described as an essential consequence of a gunshot wound, and it led me to hope that in the future, as the means of assistance as well as the surgical treatment became more perfect and complete, such a sequence as inordinate inflammatory action, instead of being very common, might only be met with as a rare and exceptional occurrence in field-surgery.

But though this desirable issue is certainly possible, even in severe gunshot wounds, under very favourable circumstances, with the advantages of complete rest, skilled attendance, and thoroughly systematic treatment, we have had comparatively few examples of such favourable results hitherto among gunshot wounds inflicted in warfare in the open field. Instances of rapid healing of gunshot wounds so inflicted have been reported from time to time, but they have generally occurred where the circumstances were such that the patients were enabled to be at once admitted into stationary hospitals, in which they remained free from exposure and disturbance, until the necessary treatment had been completed. Such conditions are rare in time of war even in Europe; they have not existed in any of the wars in which British troops have been engaged of late years. In the last war on a scale of any considerable magnitude in which an English army has been engaged, the war of 1882 in Egypt, the wounded after the battle of Tel-el-Kebir were at once attended to, and their wounds dressed antiseptically. They were then sent by very easy modes of conveyance, by canal or rail, from the field of action, and speedily

transferred to transport vessels at Ismailia, and conveyed to England. A large number of these patients, after a favourable voyage, were admitted into the Invalid Hospital at Netley, and nearly all the gunshot wounds were still in a state of suppuration, some suppurating profusely, at the time of their arrival. Perhaps the movements of the vessels during their passage, insufficiency of surgical assistance and of adequately trained attendants, and difficulties in the way of securing all the necessary attention in the kind of accommodation which is available in vessels not constructed for hospital purposes, may account for the results in the instances referred to. But in the subsequent engagements which took place near Suakim, the gunshot wounds of the patients who arrived after a voyage of about six days at the Victoria Hospital at Suez were suppurating freely, though they had been in most instances dressed antiseptically before leaving Suakim, and had adequate means of attention for the short voyage. Many circumstances have to be taken into account in explaining the different results which, as a general rule, have so far attended the antiseptic treatment of gunshot wounds in military practice, from those which have followed the same method of treatment when applied to such contused wounds as are usually met with in civil practice.

Excessive inflammation and prolonged suppuration have especially attended gunshot wounds in which injuries of bones and joints have occurred, more especially when they have been insufficiently immobilised; in cases where soldiers have been exposed to lengthened transport in springless vehicles over bad roads, whose wounds therefore have been subjected to frequent jolts and prolonged agitation; in sinuous wounds beneath fasciæ; in wounds complicated with the lodgment of angular fragments, pieces of cloth, and other foreign bodies, or that have been irritated by inconsiderate explorations in search of them by means of instruments that have been only partially freed from impurities; in cases where the wounded patients have been exposed to neglect, to extremes of temperature, to inclement weather, or where they have been in the habit of indulging to excess in alcoholic stimulants; or where they have been placed under the influence of unhygienic conditions after arrival in hospital. Under the circumstances above mentioned all the characters of the inflammation—the swelling, vascular excitement, and sensibility—are liable to become greatly exaggerated and the process of repair materially interfered with, if not for the time arrested.

Local inflammatory action, sometimes of a grave character, may occasionally be met with in gunshot wounds, yet its features be essentially different from those just described. The inflammation before mentioned generally occurs early in the case, and is itself of an active kind. But severe and extensive gunshot wounds are liable to be complicated with inflammation, which may be rather

said to be passive in its nature. This form of inflammation is usually met with at a later period in their progress. It will occur occasionally at an early period, when the wounds have been attended with much loss of blood, when they have happened to soldiers who have been much lowered in tone by over-fatigue, loss of rest at night, bad diet, prolonged exposure to wet and cold, and who, in consequence, have sunk into a generally anæmic or scorbutic condition, as was the case with most of the British troops during the first winter of the Crimean campaign. It has also been met with in patients who have been for some time under treatment in hospital. The constitution of the patient has become depressed, and under the lessened power of resistance that results from this condition, the inflammatory excitement previously existing becomes aggravated by some comparatively slender source of irritation. The local signs of inflammation are present, but they do not exhibit the same amount of active energy as the early inflammation did, which was induced by the causes previously noted. The accompanying constitutional disturbance partakes equally of a depressed character. With each of the inflammatory states just described, the process of repair in the wound is impeded or altogether stopped; but in the one instance the arrest is due to inordinate action associated with a fair amount of constitutional vigour, in the other case to inordinate action joined to a deficiency of constitutional vigour. A proper estimate of the differences in the nature of these two forms of inflammation becomes of importance when the question of treatment has to be considered.

In particular cases of gunshot wounds in which the inflammatory process has been controlled, and the patient has regained a normal or nearly normal temperature and pulse, and yet after a time an accession of local inflammation and general fever occurs, some fresh exciting cause must be looked for. It may be something connected with the wound itself, as confined pus or abscess, or the presence of foreign bodies exciting irritation, or it may be a sign of the onset of some more serious change—of approaching erysipelas, cellulitis, or of one of the forms of septic poisoning.

Inflammation in gunshot wounds entails consequences of different degrees of gravity according to its nature and intensity. When the local action is excessive, it may lead to strangulation of tissues, defective nutrition, ulceration, or mortification in parts adjoining a wound which were only indirectly damaged by the projectile, and not directly struck by it. In other instances it may induce excessive suppuration, the matter being collected deeply or being diffused, while the parts for some distance around the neighbourhood of the wound are left in a brawny unyielding condition from infiltration. In all cases, as before mentioned, it interferes with, delays, or completely arrests the natural processes of repair while it lasts.

CHAPTER II

GANGRENE AFTER GUNSHOT WOUNDS

Traumatic gangrene.—When a part of the body is penetrated or scored by a projectile armed with sufficient force, one effect of the violence, as already mentioned elsewhere, is to cause an extinction of vitality in the organised structures directly subjected to it. The mortification which ensues extends to a greater or less breadth and depth according to the circumstances of the original injury. In a wound through soft structures by a bullet of small dimensions, the destruction of tissue may be limited to the margin of the entrance opening, or to more or less of the track hollowed out by the projectile in addition; in wounds by large fragments of shell, and by all heavy missiles, the destruction caused is usually extended and deep, rarely superficial. The ordinary sequence of events is as follows: inflammation takes place in the surrounding structures, a process follows by which the mortified parts are cast away, and a renewing and healing action succeeds. The destruction of structure in such a case is limited to the direct sphere of the crushing action of the missile, and the devitalised substance is thrown off as a slough.

This is what takes place in most gunshot wounds of a simple kind under favourable conditions. The death of a certain amount of tissue is a primary and essential feature of the wound itself: it is part of the injury inflicted, and can hardly be regarded in the light of a complication of it.

Local and distant gangrene.—But under other circumstances the mortification is not thus limited. An unhealthy action spreads from the sphere of violence to parts beyond, and this secondary action leads to the death of the parts involved in it. When this destructive process takes place, it is truly a complication of the original injury. Again, the nature of the wound may be such that, in consequence of injury done to particular structures, the resulting interference with their functions, or the complete arrest of them, may lead to loss of vitality in other parts at a distance from the seat of violence itself. Thus such general mischief may be done to the vessels and nerves together at the upper part of a limb by a massive projectile, or such damage to the principal vascular trunks by a projectile even of small size, that, owing to vascular obstruction and loss of nervous influence, mortification may commence at the ultimate part of the limb, and progressively extend upwards, until a great portion of the parts below the site of the original injury may be brought into a condition of sphacelus. This progressive destruction, indirectly induced by the action of the projec-

tile, whether extending from the wound itself or commencing at a part remote from it, is what is understood by the complication of *Gangrene* in gunshot wounds. It is designated *Traumatic Gangrene,* to distinguish it from *Idiopathic Gangrene,* which, though consisting of many varieties in respect to causation, is independent of injury in its origin. The expression 'traumatic gangrene' does not particularise the complication under notice beyond indicating the fact that it originates in violence. The sphacelated parts which have been deprived of their vitality indirectly through the effects of a gunshot injury, no less owe their death to traumatism than the tissues which have been primarily deprived of their vitality by the direct impact of the projectile.

Gangrene, as an early complication of gunshot injuries, is met with, then, under two conditions, and these may be distinguished, in respect to the injury which has been their primary cause, as 'Gangrene from intense local contusion' and 'Gangrene from distant injury.' As the primary causes of these two varieties of gangrene are distinct, so is the nature of the treatment which they severally require.

Local gangrene.—The causes of gangrene which spreads locally from the seat of a gunshot injury may be either local themselves, or they may be constitutional, or, what most frequently happens, both local and constitutional causes may be combined.

Local gangrene from indirect injury.—Locally induced gangrene is most frequently met with in lacerations from heavy fragments of shell, and other projectiles of similarly large size and weight. Beyond the limits of the tissues which are directly crushed and disorganised by such heavy shot, it often happens that other tissues in the immediate neighbourhood receive so much structural damage from the pressure, extreme stretching, or violent agitation to which they have been subjected, that they are deprived of the power of returning to their normal state of activity. They become more and more cold, whatever sensibility is left in the injured parts becomes lessened, and at length vitality entirely ceases. There is no line of demarcation between the parts which have been utterly destroyed in the first instance, and the adjoining parts, which, though they have not been injured at once to this last degree, have nevertheless been mortally damaged. The distance to which this destruction extends will vary according to the size, weight, and force of the projectile. If the damage be within moderate limits, and the wounded man is in good general health, all may go well, repair taking place in the same way as when there is only a mere superficial slough; but if they be so extensive as to materially interfere with the integrity of the limb in which the injury has been inflicted, or from other causes, grave constitutional depression ensues, then the process of mortification may go on spreading, and invading structures which could hardly have

been affected by the original injury, until the patient at last sinks under its effects. There is not sufficiency of power on the part of the more or less damaged tissues to establish a barrier between themselves and those which have been directly destroyed by the original injury, and they succumb to the deleterious influences, direct and indirect, of the mortified parts in their immediate vicinity.

Local gangrene following excessive inflammation.—On other occasions inordinate inflammation, that is, inflammation in excess of the strength of the tissues involved in it, appears to cause the occurrence of gangrene. The excess of inflammation in such cases is generally ascribed by modern pathologists to an accession of micro-organisms in the inflamed tissues or the discharges emitted by them. The usual signs of inflammatory action, which are presented up to a certain point, disappear from the parts immediately around the wound; and, in their stead, those of commencing mortification take their place. The comparatively sudden change from heat, pain, and redness in the parts to coldness, insensibility, and loss of circulation, in the absence of any other explanatory cause, seems to leave no doubt that the relatively excessive inflammation has itself been the cause of its own cessation.

Local gangrene in relation to extent of injury.—When the depth and breadth to which parts have been injured by a large gunshot projectile are very considerable, this circumstance alone may widen the limits of local gangrene by interfering with the supply of blood and nervous energy to the adjoining structures. Thus, if a mass of shell inflicts a violent contusion on a part of an extremity, and nearly the whole circumference of the probably tensely swollen limb is involved in the injury, gangrene will almost surely extend to a considerable distance if the patient survive, because the sanguineous and nervous currents which are necessary for the preservation of the vitality of the limb are in a great degree, if not wholly, arrested. But the large extent of surface injured, and consequent shock to the constitution, certainly influence in some cases the fact of a wound being followed by spreading gangrene instead of by healthy action, independently of any arrest of the supply of blood to the parts which become gangrenous. I have before referred to the case of an officer in the Crimea who was wounded at the final assault by two grapeshot. The wounds were simple flesh wounds, without injury to any vital organ. Both shot had, however, severely crushed the opposing tissues, and had penetrated deeply; one lodging in the muscles of the back, the other passing from the back into the inner aspect of the upper arm, but without injury to the axillary or to any other vessels or nerves of importance. In this instance the superficial sloughs were not eliminated, the œdematous swell-

ing extended, and the gangrene slowly went on spreading along the areolar tissue and neighbouring structures, accompanied by great nervous irritability and constitutional disturbance, until the patient died. There was no attempt to form a line of demarcation between the dead and the adjoining tissues. The extent of injury seemed to be the chief cause of the gangrenous degeneration, for, although the wounds from the first were accompanied by much shock and general stupor, the patient's constitution was to all appearance in a good state at the time his injuries were inflicted, notwithstanding the duration of his service in the Crimea, which had been considerable. The appearance of bodily strength and health may, however, have been deceptive. The hygienic circumstances under which he was placed after the injury were of the most favourable kind. This was sufficiently proved by the satisfactory progress made by two other patients with almost desperate wounds who occupied the same hospital hut with him.

Recurrent gangrene.—In the majority of wounds in which gangrene occurs, the disease will not proceed to the fatal extreme just mentioned. Either the gangrene, when suitably situated, will be arrested by local treatment, or the parts involved in it will be removed by operative interference, or it will cease naturally from a cessation of the unhealthy action. But in these comparatively favourable cases, after an apparently vigorous healing action has been established, the sloughing may recur, without any cause for suspecting a contagious origin, as in hospital gangrene. There were numerous cases in which such recurrent gangrene occurred during the Crimean war. As they were generally accompanied with more or less indications of constitutional disturbance on the occasions of the recurrence, the inference was that they were chiefly attributable to general systemic derangement, due, perhaps, to the deleterious influence of septic products in the air of the ward, rather than to any direct influence, such as contagion.

Spreading gangrene in soldiers wounded on active service.—Among the causes which determine whether an injury by a massive projectile is followed by an eliminating and curative process, or whether it becomes complicated with spreading gangrene, it is obvious that the state of the patient's constitution at the time the injury was received must always act an important part. If the constitution be depressed from excessive hæmorrhage or any cause, according to the degree of that depression will be the lack of power in those parts that have been indirectly injured by the projectile, and their inability to sustain the strain they must undergo during inflammatory action, so as successfully to detach themselves from the parts directly destroyed by the projectile. The spread of gangrene in a soldier much lowered in tone is in some respects analogous to the effect of mechanical pressure in the production of a slough and bedsore in a patient weakened by

prolonged disease. An energetic action is required to separate and throw off the mortified parts, but the previous state of the bodily structures concerned and the superadded injury prevent it. Among soldiers in time of war the causes of lessened constitutional vigour are very numerous. Their effects are often not manifest enough to be recognised by unprofessional observers, but they make themselves very apparent when they are subjected to the test of injury or illness. A scorbutic taint and chronic bowel derangement, induced by bad diet, depression of vital force, and pyrexial disturbance from loss of rest at night, from excessive and harassing fatigues, and from exposure to inclement weather of all kinds, have hitherto been common circumstances in campaigning. When to these are added loss of blood from a wound, confinement in hospital, and that nervous depression so constantly observed with sloughing wounds of much extent, it is evident that any unhealthy local action of low type may readily occur.

Gangrene from cold in the Crimea.—The effect of constitutional depression in creating a tendency to gangrene was witnessed to a large extent during the first winter in the Crimea in the so-called cases of 'frost-bite.' They had no analogy in character, appearance, or mode of progress with the cases of mortification produced by the effects of intense cold in northern regions on healthy subjects. Having been familiar with the appearances of frost-bite in North America prior to the time of the Crimean war, I was able to recognise the marked differences which the Crimean cases of frost-bite presented. The mortification during the winter did not take place in the exposed parts of the face, the ears, the nose, and other parts, as so frequently happens under low temperatures in cold climates; nor were those other cases met with in which, when parts of the body or extremities have been partially frozen, mortification is induced by an imprudently hasty application of warmth to the frozen parts. In the Crimea nearly all the cases began in the extremities—in the toes and feet of men in whom excessive bodily fatigue, bad and insufficient nutriment, loss of rest, protracted exposure to damp without the means of procuring a change of clothes or ordinary warmth, and diarrhœa, had induced a condition of extreme anæmia and physical debility. The circulating fluid of the body was not only deficient in all the qualities of healthy blood, but the arterial system had hardly sufficient propelling force to distribute this fluid, such as it was, to the extremities. There was probably not an officer or a man who was engaged in the siege operations at the front before Sebastopol throughout the early months of the winter of 1854–55, but had acquired a scorbutic condition of constitution to a greater or less extent. No wonder, then, that in numerous instances, when boots, sodden with damp

from the muddy trenches and kept on day and night, or frozen from marching through the snow, were cut off the numbed and swollen feet, it was found that mortification had already commenced. Cold, doubtless, was one ingredient in the production of the gangrene, but it was a very trifling one compared with others; indeed, in a very large proportion of cases the so-called 'frost-bite' took place when the temperature was considerably above the freezing-point. During the second winter—the winter of 1855–56—the circumstances were all different. Some true cases of gangrene from exposure to cold then occurred, but they were few in number compared with those of the first winter, notwithstanding a large increase in the number of troops on duty; while the deaths, which amounted in the first winter to 457 from the cause above named, in the second only reached six in number.[1]

Gangrene during the war in the United States.—A table is furnished in the Surgical History of the War of the rebellion which shows the distribution and results of 2642 cases of gangrene treated during the war. This table includes all forms of gangrene occurring after shot wounds. It was found impracticable to differentiate the kinds of gangrene, and to arrange them in special groups, from the descriptions given of the cases in the reports recorded during the war. Of the total number (2642) of cases, the gangrene complicated wounds of the upper and lower extremities in 2366 instances; wounds of the trunk, in 216; and wounds of the head, face, and neck, in 60 instances. Nearly two-thirds (1522) of the 2366 cases in the extremities occurred in the lower extremities, though the wounds in the upper were rather more numerous than those in the lower extremity. The issues of the 2642 cases were—1142 terminated in death, 1361 in recovery, while in 139 instances the results were not recorded. Attention is called in the remarks attached to the table to a peculiar feature shown in it, viz., that the percentage of fatality in the instances of gangrene of flesh wounds was larger than in those complicated with fractures. The death-rate in cases of flesh wounds of the upper extremity attacked by gangrene was 51·5 per cent.; in cases of fractures similarly attacked, 33·9 per cent.; the mortality among gangrenous flesh wounds of the lower extremities was 50·3 per cent., while among those with fractures of bones it was 48·7 per cent. Of the total 2366 cases of gangrene in the extremities, it occurred after excisions of joints in 185, while it attacked the faces of stumps after amputations in 898 instances. The history states that the large majority were cases of Hospital Gangrene fostered by the crowded state of the hospitals, and the large numbers of extensive fractures and severe operation wounds among the patients.[2]

Rapidly diffused gangrene after gunshot wounds.—In the descriptions of local traumatic gangrene hitherto noticed, the

morbid action extends gradually, either marching on regularly day by day, or advancing with occasional halts. Sometimes, however, after a severe gunshot wound, gangrene will suddenly spread with such fatal rapidity, that it appears to invade the adjoining parts for some considerable distance almost at one and the same time. If, instead of occurring in individual instances, and in some degree to be accounted for by the extent and gravity of the original wound, by the shock which has attended it, and generally also by the low degree of vital energy in the patient's constitution, it occurred among a large number of cases in which wounds of all degrees of gravity, and patients of all states of constitution, were attacked alike, the gangrene would hardly be distinguishable from true 'Hospital Gangrene.' It is not, however, accompanied with the intense burning or stinging pain which is so characteristic a symptom of hospital gangrene, especially at the onset; nor is there any ground for attributing a contagious character to it. It has chiefly been observed after injuries of the lower extremities from some of the larger forms of projectiles, especially when not only the soft parts but bone has suffered, and amputation has not been practised in the hope of obtaining a cure by conservative treatment. The features of the attack are very strongly marked. The wound suddenly becomes greenish and dark in colour, softens down, and emits a most offensive odour. The whole limb at the same time becomes swollen and œdematous; in parts, perhaps, is of an almost cartilaginous hardness; the skin loses its normal pinkness, and presents a dull white colour like tallow, then assumes a mottled appearance, and not unfrequently becomes studded with bullæ. The areolar tissue, along which the gangrene seems to have a special tendency to spread, becomes disintegrated and converted into a substance of semi-purulent pulpy consistence. The patient's constitution exhibits indications of having become suddenly invaded by septic poisoning; there is great systemic excitement with prostration; and the attack speedily leads to a fatal issue. Examination of the limb after death shows not only the cellular tissue broken down and putrid, but the muscles softened and changed in colour, and, in fact, a gangrenous condition, more or less advanced, of all the structures. The attack in all such cases is manifestly preceded by a form of blood-poisoning, probably produced by absorption of chemical products or morbid material from the decomposed tissues of the wound itself; neither simple depression of vital force nor shock alone suffice to explain it, as in instances which have been previously mentioned.

Suddenly developed local and general gangrene.—In some instances among the British in the Crimea, and also among the French in the hospitals on the Bosphorus, gunshot wounds, but more particularly amputations consequent on them, were followed

by a form of gangrene of even a still more formidable character than that which has just been described. No cases of the kind had been previously recorded as distinct from traumatic gangrene in general by English writers. Dr. Lyons, in his report on the Pathology of the Diseases of the Army in the East, has described it under the designation of *True Local and General Gangrene.*[3] According to the Official Surgical History of the War, it was supposed to have occurred only in one hospital in the Crimea, the general hospital in the camp,[4] where it attacked certain patients who had suffered specially severe injuries. But Dr. Lyons also met with it in other situations. The first case was noticed during the month of June, in a patient who had undergone amputation of the thigh for gunshot injury. 'Attention was first attracted by the peculiar shrunken collapsed state of the features, so familiar in the algid state of cholera, and the coincidence was remarked that cholera prevailed with peculiar severity at the time in the camps of the regiments surrounding the hospital, and especially in the two nearest, viz., those of the 39th and 14th Regiments, from which most of the orderlies of the hospital were furnished.' In the description of the symptoms in the official history, many of the appearances characteristic of an attack of cholera are described as having been present, such as collapse, sunken eyes, thirst, lividity of face, and coldness and clamminess of surface; but the attack was not preceded by vomiting or diarrhœa, neither were cramps observed.

Dr. Lyons states: 'The disease commonly appeared about the fourth, fifth, or sixth day. It was generally preceded by pain, more or less severe in the stump; there were also symptoms of general constitutional disturbance, sometimes violent, tumultuous, of sudden occurrence, and not easily explicable; but these were not constant, and in some of the very worst cases there was little to indicate the danger of the patient, and he was himself the last to suspect it. In several instances the morbid state, fully developed, though previously unsuspected, was first indicated by a peculiar intense odour emanating from the parts, and sensible at some considerable distance, and which, though difficult to be described, could never be mistaken after it had been once recognised. To those familiarised with it, this odour was perceptible upon entering the ward where the patient lay. On examining a stump thus affected, the flaps were found discoloured and gaping; the whole limb was immensely distended, and in parts distinctly emphysematous; vesications filled with discoloured serum were not unfrequently found near the borders of the flaps; fœtid gas and a sanious dark-coloured fluid bubbled out from the wound; the areolar and adipose tissues, discoloured and apparently dead, protruded between the sutures where any of them remained. The upper parts of the limb were white and tallowy in appearance, and

sometimes marked with a network of purple-coloured veins. The parts were insensible throughout, and the temperature was considerably diminished. The action of the heart was feeble, and the pulse excessively rapid, but weak. Death invariably supervened within a very short period; its occurrence was seldom protracted beyond twenty-four hours from the time at which the state was first discovered.' The description of Dr. Lyons agrees in all essential particulars with that in the Official History of the War. In the latter it is added that the removal of the dressings and sutures from a stump attacked by this form of gangrene was followed by the escape of a considerable quantity of fœtid gas, as if by explosion, attended with some relief of the pain and sense of constriction; and that, what appeared remarkable, notwithstanding the decomposition of the tissues, ligatures on vessels in all the cases held firmly. Neither local nor constitutional remedies had any effect in arresting the progress of the gangrene. The official history states that no case appeared to have occurred after July the 14th; but in the cases cited by Dr. Lyons there is one which he describes as the most rapidly fatal case which he had seen, and this took place in a young soldier who received a gunshot fracture of the right leg on September the 8th, for which amputation was performed the same day.

The appearances presented on examination after death are described in full detail in Dr. Lyons' report, but are too long to be quoted. The following concluding remarks of the report contain all the most important particulars regarding them, as well as the views which Dr. Lyons was led to entertain regarding their immediate origin: 'Death of the parts more immediately concerned in the operation, gaseous distension of the limb, and more or less general emphysema of other parts of the body, almost total disappearance of the blood, and its replacement in the heart and vessels by gas, with more or less advanced decomposition in the viscera, have been the chief appearances found after death. The disease, as far as we know, has not a recognised connection with any particular age or type of constitution. We have seen it in the lad of eighteen, of light and active frame, and we have also met with it in the robust, stalwart, and perhaps too plethoric artilleryman. It has shown no tendency that we could ascertain to spread by infection or contagion. But on the occasions of June the 8th and 18th, the final assault on the Great Redan on September the 8th, and after the fatal explosion in the Right Siege Train on November the 15th, and in rare instances in the intervals between these periods, well-marked examples of it have been presented. There seems no way of accounting for these very remarkable phenomena, except by the supposition that they are the result of a sudden and general decomposition. The immediate origin of this decomposition may, not without some probability, be referred to a

local, suddenly developed, but intense gangrene of the parts at the seat of injury or operation, which, by a sort of pathological catalysis from the effects of the local organic decomposition, determines in the first instance a decomposition of the blood, and, through this medium, that of all the tissues with which it comes in contact It is remarkable that the various tissues and organs did not present the appearance of being merely dead, and spontaneously undergoing decomposition as in ordinary cases, but they seemed to show, in the changes so rapidly and intensely produced, the effects of a peculiarly destructive agency. The explanation of this agency is probably to be sought in the sudden and as it were explosive decomposition of the circulating fluid, its chemical constituents assuming the gaseous form in a sudden and violent manner, and the resulting gases in their expansion causing a mechanical separation and disintegration of the particles of the tissues.' No case of this formidable description of gangrene, which, from the simultaneous occurrence of the local and general changes, might have been almost called 'concurrent local and general gangrene,' came under my own observation during the war; and I have therefore thought right to quote at some length the observations upon it of Dr. Lyons, as his position of Pathologist with the Army in the East gave him special opportunities of observing it.[5]

Both the terrible form of gangrene just described, as well as the diffused gangrene referred to in the preceding paragraph, are now generally explained as being due to the poisonous influence of micro-organisms which have found their way into the connective tissue through the wound openings, together with their very rapid development and diffusion through the surrounding structures. There still remains to be satisfactorily explained why the invasion appears in individual cases, while others that appear similar in nature, and that are placed under the same conditions as regards locality and their surroundings, escape. However this may be, micrococci are said to be invariably found in abundance in the offensive purulent fluids and necrotic tissues of a part which has become the subject of moist gangrene, such as single cocci in chains of the streptococcus pyogenes, and the staphylococcus pyogenes albus also existing singly as well as in zoogloeaform masses.

Distant gangrene.—Distant gangrene, when it follows gunshot injuries, is usually the result of some damage done to the principal vessels at the upper part of a limb, so that the supply of arterial blood to the distant parts, and generally the return of the venous blood from them, have been suddenly impeded. This may be the effect of a crushing injury by a large projectile in which the principal vessels are equally with other structures functionally destroyed; of contusion by smaller projectiles leading to obstruction

both of the artery and vein; of contusion of the artery leading to constriction, though not to complete closure of its calibre, together with contusion and blocking up of the principal vein; of a wound of a vessel by a spicula of fractured bone, with extravasation and pressure as a consequence; or of direct division of the principal artery of the limb by the projectile. Any cause which may lead to an arrest of the general circulation in a limb which has been subjected to gunshot injury may equally entail gangrene as a consequence. If a patient, shortly after a wound near the principal vessels of the thigh, complain of coldness and numbness in the foot, heaviness of the limb, and pain in parts; and if, further, the skin should assume the peculiar colour and appearance which Mr. Guthrie has graphically described as those of a tallow-candle, passing into the aspect of mottled soap, even though no important bleeding may have occurred at the time of the injury or subsequently to it, a lesion of the vessels sufficient to cause gangrene may at once be suspected. All doubt on the subject is removed if, on placing the finger over the vessel, the pulsation, which is felt in the artery above the wound, ceases to be perceptible below the seat of injury. Under such circumstances, if left to itself, the gangrene will gradually ascend, until at last a line of demarcation between the gangrenous and living parts becomes established, and eventually, if no evil happens, natural amputation is effected; or, what is the more probable issue, the gangrene, rapidly extending, will assume such proportions that the patient dies from the effects of the constitutional irritation or septic intoxication produced by it. There is no difference between the characters of the distant gangrene itself and those of local gangrene, although the causes which produce them are different. The particular study of this form of distant gangrene finds its natural place with the subject of wounds and injuries of the blood-vessels.

Dry gangrene.—Instances of dry gangrene as a consequence of *gunshot wounds* have very rarely been recorded by military surgeons, but 9 instances of it are described in the Surgical History of the War in the United States (see Part III., p. 850, &c.), and some admirable chromo-lithographic representations of the disease are given in the volume. In all the 9 instances the feet or toes were the parts affected, and the gangrene was due to interference with the arterial circulation. In 5 of the 9 cases amputation was performed after the appearance of the gangrene, and 4 of these recovered; in the remaining 4, all of which terminated fatally, no operative interference was resorted to. Particulars of the 9 cases are given in the history.

CHAPTER III

SECONDARY HÆMORRHAGE AFTER GUNSHOT WOUNDS

General remarks.—This complication is always an alarming one to patients, and a source of great anxiety to surgeons. In occasional instances, when a large vessel is the source of it, secondary hæmorrhage occurs so suddenly and so profusely, that, unless a surgeon happens to be present at the moment of its occurrence, it very quickly leads to a fatal result; and in almost every case it is a symptom indicative of a hazardous condition of the patient. It has hitherto been a too frequent complication of gunshot wounds. It is particularly liable to happen when wounds are attended with spreading gangrene, excessive suppuration, or any variety of septic poisoning, especially when the sanitary state of the hospitals in which the wounded men are treated is bad, or the wards are overcrowded. Under the last-mentioned circumstances secondary hæmorrhage has also been a frequent complication after amputations consequent on gunshot injuries.

Modes of its occurrence.—The manner in which secondary hæmorrhage occurs differs in different cases. In some instances an indication of its approach is given to the surgeon by the escape of a small quantity of blood, the flow of which may either stop spontaneously, or be temporarily arrested by appropriate means. This flow may then recur after a time, increasing in quantity, until at last the necessity for active surgical interference is thoroughly indicated. Or, instead of this happening in moderate amounts at successive times, a copious flow may suddenly take place from a wound without any previous warning, and the patient's life be placed in immediate danger unless steps can be taken at once to avert the fatal issue which is imminent.

Frequency of its occurrence.—It has just been remarked that gunshot wounds have not unfrequently been followed by secondary hæmorrhage. As with other complications of these injuries, so with this, exact information cannot be afforded respecting the proportionate number of cases in which it has hitherto occurred, either when regarded as an average, or on particular occasions. The deaths which have been due, either directly or indirectly, to secondary hæmorrhage are usually shown in army numerical returns under the name of the original injury, or under that of the amputation or other surgical operation consequent upon it. Hence some surgeons describe secondary hæmorrhage as less frequent than others admit it to be; the views respecting its frequency having been derived from the varying kinds of returns put forth by different observers. Moreover, if the statements expressed

regarding the causes which lead to its prevalence be correct, it may be readily understood that the experience of surgeons as to its relative frequency must have differed greatly according as the circumstances under which the injuries have been treated have differed. There can be no ground for doubting that under the improved methods of treatment now adopted for gunshot injuries, secondary hæmorrhage ought to be of much rarer occurrence in future than it was in former days.

Period of its occurrence.—Secondary hæmorrhage is understood to mean that which takes place subsequently to the time at which primary hæmorrhage has been arrested, whether by natural or artificial means; or, in cases where no primary hæmorrhage of moment has occurred, subsequently to the time at which such hæmorrhage ordinarily happens. The period during which secondary hæmorrhage may occur may be more or less remote; it may vary from four or five days to three weeks, or even upwards, after the infliction of the wound.

It is necessary to distinguish secondary hæmorrhage from simply recurrent or delayed primary hæmorrhage. It may happen in field-surgery that the ligature placed on a wounded artery hastily at a dressing station becomes loosened, or even detached, during the subsequent movements of the patient while he is being carried, often in unsuitable transport conveyances, to hospitals placed at a distance in the rear; or the clot by which the extremity of a divided vessel has been temporarily occluded may be forced away by the jolting to which the patient is subjected, or by his own movements, or in the course of an exploratory examination of the wound at a field hospital, and the hæmorrhage which had stopped may then break out afresh. Not unfrequently, also, after the arrival of wounded men at field hospitals, vessels which had not bled or been seen to bleed previously, owing to the condition of shock or faintness under which the patients had laboured, together with the effect of the open air upon their wounds, will commence to bleed because the circulation has become more active under the influence of warmth and the restoratives administered. It has occurred that divided vessels have been temporarily occluded by pressure due to the very projectiles which have injured them, and have bled copiously when these foreign bodies have been taken away. These occurrences, though not immediately following the infliction of the wounds from which they are derived, are manifestly not cases of secondary hæmorrhage. They may be called intermediate; but, though occurring between the time when primary hæmorrhage from a wound ordinarily occurs, and the time when hæmorrhage due to secondary causes is usually met with, they do not differ in any important degree as regards their nature, the condition of the parts concerned, or the treatment required, from cases of primary hæmorrhage.

Dr. Thomson has stated in his Report of Observations made in the British Military Hospitals in Belgium after the battle of Waterloo,[6] that, judging from notes in his possession of above fifty cases of secondary hæmorrhage which occurred among the wounded at that time, it varied in the time of its occurrence, but was most often met with after the twentieth day from the date of the original wound. He was doubtful, however, whether this represented the general period of its occurrence. In many of the cases referred to by Dr. Thomson, the hæmorrhage arose from sloughing of arteries occasioned by hospital gangrene. In others the hæmorrhage was of the capillary kind, that is, was not due to escape of blood from any particular vessel obvious to view, but occurred apparently as an effect of generally increased determination of blood to the walls of the canals of gunshot wounds, or of the surfaces of stumps after amputation. Dr. Thomson ascribed the hæmorrhage in the last class of cases to accidental circumstances, such as the injudicious administration of too liberal an allowance of stimulants and animal food to patients of a plethoric temperament; but, although this may have been the exciting cause among the wounded in the Belgian hospitals, it is certain that cases of secondary hæmorrhage, having precisely similar characters, were frequently met with during the Crimean war under very opposite conditions. Secondary discharges of blood, in the form of capillary oozing, were frequently witnessed in the Crimea among the wounded, when the men had become so reduced in constitutional tone by the trying circumstances of the siege, especially during the first winter and ensuing spring, that no surgeon could have thought of resorting to the antiphlogistic methods of treatment recommended by Dr. Thomson, as the results of his Waterloo experience, for their prevention or alleviation.

Special varieties of secondary hæmorrhage.—Attempts have been made by several military surgeons to allot different periods of time for the occurrence of particular varieties of secondary hæmorrhage. Dr. Thomson, to whose experience among the wounded in Belgium reference has just been made, divided secondary hæmorrhage into three periods, and allotted special causes to each period. Secondary hæmorrhage of the first period, or from the second to the fifth day, he ascribed to the recently closed mouths of arteries being opened by increased force of circulation; of the second period, from the fifth to the tenth day, to ulceration or sloughing of the coats of arteries, most frequently to sloughing; while he regarded the secondary hæmorrhage of a still later period, between the twentieth and thirty-fifth day, as either capillary or occasioned by hospital gangrene. Guthrie has stated that secondary hæmorrhage, whatever the cause, usually occurs between the beginning of the second and the fourth week,[7] that is, from the eighth to the twenty-eighth day. Hennen and other army

surgeons have named other periods when secondary hæmorrhage may be expected. From the discrepancies in the statements on this point, it is obvious there is difficulty in assigning the limits of its occurrence with any approach to precision; and, considering the very different causes to which the complication may be due, and the accidental nature of some of them, it may reasonably be concluded that uncertainty must always exist regarding the time of its occurrence, no less than on the occurrence itself. No wounded patient, indeed, can be considered to be absolutely safe from secondary hæmorrhage so long as his wound, when it is a deep one, and especially if it be complicated with fracture of bone, remains open and suppurating. It may be reasonably expected, however, that in wars of the future, with the advantages derived from antiseptic precautions in the treatment of gunshot wounds, suppurative inflammation will not be met with either of so profuse or so prolonged a character as it has been after the wounds inflicted in past wars, so that, as a consequence, secondary hæmorrhage will also be less frequently witnessed than it has been hitherto by army surgeons.

Local causes of secondary hæmorrhage.—Secondary hæmorrhage may have either a local or general origin, and it becomes important to separate the two kinds of causes when the question of treatment is considered. Among the local causes may be enumerated cases of ulceration of a ligatured vessel due to excessive disturbance of the connections of the vessel, and interference with the means of the proper maintenance of its vitality, at the time of the application of the ligature; too strong an application of a ligature, so that the outer coat of the vessel has been partially divided at the time of the operation, and the ligature becomes detached before the hæmostatic process has become completed; or too loose an application of the ligature, so that the vessel has not become properly sealed at the time of its detachment; ulceration or sloughing of the coats of the vessel, as a consequence of injury done to it by the projectile at the time the wound itself was inflicted; the same accident owing to unhealthy inflammation, diffused areolar suppuration, or spread of gangrene under septic influences among the textures in the neighbourhood of the vessel, and the invasion of tissues immediately adjoining it; too dependent a position of the wounded part, or accidental injuries in the course of treatment; and, lastly, the continued pressure of a lodged projectile against a vessel, or its penetration by a sharp point or edge of a fragment of a projectile, or spicula of fractured bone. Of these local causes of secondary hæmorrhage, probably the most frequent is that in which a vessel of considerable size has been severely contused by a passing projectile, so that ulceration or sloughing of its coats occurs subsequently. In these cases the hæmorrhage does not usually take

place until a week or so after the receipt of the wound—probably not till some time in the course of the second week after it, when suppuration has become fully established, and sloughs are being thrown off from the surrounding tissues. But a sudden start of the patient, or some excessive exertion or passionate excitement, may bring on the hæmorrhage at any moment, when the parts are thus in a favourable condition for its occurrence. This, however, is equally true whether the tendency to the secondary bleeding have its origin in local or constitutional causes.

General causes of secondary hæmorrhage.—Among the general causes of secondary hæmorrhage, all those diseased conditions of the constitution may be included which induce such a deteriorated state of the blood as lessens its coagulability and unfits it for performing its part in the process of hæmostatic repair. Again, all those circumstances may be reckoned as general causes of secondary hæmorrhage which so frequently occur in campaigning, by which a scorbutic taint or condition of anæmia is induced. Whenever this state of system has been engendered, the constitutional powers are lowered to such an extent as to impair the vital energy of the arteries themselves as well as of the tissues immediately surrounding them; and hence that portion of the process of obliteration of an artery, which depends on the effusion and consolidation of healthy lymph within and around the vessel, the importance of which in securing it against secondary hæmorrhage has been sufficiently established, is impeded or altogether prevented. Secondary hæmorrhage under such circumstances is an almost inevitable occurrence. It is often difficult in field practice to determine how much such accidents are due to a merely depressed state, how much to a poisoned state, of the patient's circulation. In general, when troops are subjected to excessive fatigue and exposure, and are at the same time ill-nourished, the hospitals from these very causes become simultaneously overcrowded; so that while on the one hand the men are deprived of their natural vigour and power of resisting disease, on the other hand they are placed in a vitiated atmosphere, and are subjected to septic influences which are especially favourable to its development and spread. When men thus debilitated become the subjects of gunshot wounds, and are so housed for treatment, the instances of secondary hæmorrhage may be expected to increase in number in proportion to the intensity of the two agencies under notice. General oozing of blood may equally be looked for from the faces of stumps after amputation, and great difficulty may be experienced in permanently arresting the flow. If the hæmorrhage be recurrent and considerable in amount, the already depressed vital power of the scorbutic or blood-poisoned patient becomes lowered in a rapidly increasing ratio by the repeated discharges of blood and the

unhealthy conditions by which he is surrounded, and he sinks, either with symptoms of general exhaustion or of fully developed septicæmia or pyæmia.

Secondary hæmorrhage as a sequence to venous thrombosis.—Dr. Stromeyer called particular attention to the frequency with which he had observed secondary bleeding in subjects of gunshot wounds of the extremities in whom blood-vessels had been injured, especially when some of the principal veins of the extremity in which the wound was situated had become obstructed through the occurrence of thrombosis, and the circulation of the whole limb had in consequence become more or less impeded. His experience led him to state that under such circumstances the hæmorrhage might be either arterial, venous, or capillary. It mattered not whether the source of the venous obstruction was of a septic nature or had a purely local origin; according to Dr. Stromeyer, the bleeding was equally liable to occur. The healing process, which might have commenced, or have advanced considerably, would retrograde, and the injured vessels, even though they had already become closed, would then reopen.

CHAPTER IV

HOSPITAL GANGRENE AFTER GUNSHOT WOUNDS

General remarks.—One of the gravest and most destructive complications to which gunshot wounds have hitherto been subject is hospital gangrene. This complication has been described under various designations: under names expressive of some of its characteristic features, as Phagedæna Gangrænosa, and Putrid Ulcer of Wounds; Hospital Gangrene, Hospital Sore, Pourriture d'Hôpital pointing to its special habitat, viz., hospitals where many wounded patients are collected together; Gangræna Contagiosa, from a belief that the direct local application of a special poison was essential to the production of the disease; Typhus des plaies, or Wound-Typhus, by others who supposed the disease to be a local manifestation of the effects of the same poison as that of Typhus Fever; and Diphthérite des plaies, or Wound-Diphtheria, from the peculiar membranous exudation by which some forms of the disease are characterised. The doubts regarding the nature of the disease exhibited in these various designations have been greatly cleared away by the researches of modern pathologists, who have sufficiently shown that the destruction of the tissues in hospital gangrene is associated with, and probably due to, special micro-organisms, or to the septic products or excretions to which they give rise, and that when once these poisonous fluids are generated,

inoculation of a healthy animal structure by them will suffice to reproduce disease of the same nature and character.

But although the pathological condition has thus been rendered so far manifest, it is none the less important for military surgeons to be acquainted with the circumstances which have seemed to lead to, and at least have fostered, the outbreaks of hospital gangrene which have occurred from time to time in military practice. In proportion as the conditions which contribute to the development of the disease are understood, so will be the means by which its outbreak may be frustrated. It is equally important to be familiar with the particular features of the disease, for its early recognition is essential for its successful arrest when it appears. There is hardly any probability that it will ever be witnessed in future wars in the intense form in which military surgeons used to have to deal with it, or that it will ever be met with in similar frequency. The greater attention given to the preservation of the health of the men in the fighting ranks, and their consequent greater power of resisting disease and the effects of injuries, the efficacy of the antiseptic treatment of wounds of all descriptions, the general enforcement of sanitation, the improved ambulance transport arrangements, and the greater facilities for disseminating the wounded, are calculated to lessen the likelihood of the occurrence of hospital gangrene, as well as the severity of its character, in case of its appearance. But it is never possible in war to make events sure, and still less so under the uncertain results of the vast increase in the sizes of armies, of the new weapons, and of the many strategic changes that have taken place of late years among the leading European Powers. It would consequently be unwise to dismiss the subject from consideration, or to act as if the total exclusion of hospital gangrene from military hospitals were a settled matter.

Former types of hospital gangrene in military hospitals.— Very few army surgeons of the present day have had any opportunity of witnessing hospital gangrene in the virulent epidemic form under which it formerly presented itself; because the means of preventing its occurrence, and of arresting its progress when it has broken out, have been of late years more adequately apprehended. It is to the writings of a former generation of surgeons that the inquirer must turn for descriptions of the disease in its epidemic and most aggravated characters. During the Peninsular war, hospital gangrene attacked the patients in some of the British military hospitals in Spain, Portugal, and the Netherlands, and spread among them with frightful intensity. Several of the medical officers who practised in these hospitals have left records of their observations and experience, particularly Dr. Hennen, Dr. Blackadder, Dr. Boggie, and Mr. Guthrie. Mr. Guthrie has put on record the number of cases which occurred at the

station hospitals in the Peninsula between the 21st of June and the 24th of December 1813. By this return it is shown that 1614 cases of hospital gangrene, mostly among the wounded from Vittoria, were treated at Santander, Bilbao, Vittoria, and Passages, and that of this number 512 died, 980 survived to be discharged from hospital, while 85 were still under treatment at the close of the period named.[8]

Hospital gangrene prevailed at Antwerp among the wounded from the battle of Waterloo, and, after a time, in some of the hospitals at Brussels. It committed severe ravages among the British wounded in the Sikh campaigns of 1845. The description of it by the late Inspector-General Taylor, C.B., as it occurred in the 29th Regiment at Ferozepore, in India, has been published by Mr. Guthrie.[9]

Hospital gangrene in British hospitals during the Crimean war.—Hospital gangrene did not attack the wounded of the British army in the Crimea. There were, as before mentioned, numerous cases of ordinary traumatic gangrene; but of true contagious hospital gangrene, not only did it never occur endemically, but in only one hospital did it appear at all, and then only to a limited extent. Certainly no instance of it occurred in any of the hospitals with which I was acquainted during the entire war. The immunity of the British hospitals in the field from hospital gangrene was the more remarkable as, according to the reports of French surgeons, the disease prevailed extensively in some of the French and Russian military hospitals during the same war.

The exceptional instance in the British army occurred in the hospital huts of the 79th Highlanders, where typhus fever was rife at the time. It was referred to by Dr. Goldie Scot, surgeon of the regiment, in his monthly report for March 1855, in the following terms: 'A bad form of phagedænic sloughing occurred in the hospital, which appeared to be contagious; and had many wounded existed at the time in the regiment, they would have fared but badly. They were, however, few in number, and consequently only one case of gunshot wound died from the disease. It attacked every variety of wound indiscriminately, from a cut finger to an open bubo.' The hospital huts, as well as those in which the men of the regiment habitually lived, were placed under very insanitary conditions. The ground on which the huts were erected consisted of plastic and very retentive clay; it was undrained; the huts were sunk from two to three feet in the ground, and were situated close to the breastwork. The suggestions which the surgeon made in order to avert or mitigate these deleterious conditions were not adopted; they were stated to be impracticable for strategic and engineering reasons.

The morbific condition of the hospital at the time this outbreak of hospital gangrene occurred is forcibly depicted by Dr.

Scot, and seems to explain its occurrence so thoroughly, that I insert the account in his own words: 'From the 1st to the 15th of April, the endemic of remittent typhus was at its height. The horrors of that period can never be effaced from the memory of those who had to cope with its difficulties. The hospital huts were unavoidably much overcrowded, and the means of attendance were quite inadequate. The two assistant surgeons were lying prostrated by fever. No less than three non-commissioned officers, who had in succession taken the duties of hospital sergeant, were attacked by the disease, and orderly after orderly succumbed to its virulence. Fortunately I was enabled to struggle on to the 16th, when, exhausted by bodily fatigue, and driven nearly to despair by anxiety, I was attacked by the fever, which nearly proved fatal. I had, however, the satisfaction of knowing before I was taken ill that the long-desired and frequently-urged measure, which strategic reasons had prevented from being adopted at an earlier date, of moving the hospital and regiment, was to be carried out. Almost every case of fever this month assumed the maculated typhus form, and I can safely affirm the disease was never seen in a more virulent form than that in the hospital of the 79th Regiment. A few of the men were quite idiotic for weeks after recovery, and hallucinations of the most extraordinary character were very common.'

It can hardly be doubted that the same insanitary conditions which led to the production of the typhus fever, combined with the overcrowding of the patients in the hospital huts, originated the tendency to phagedæna, and conferred on it the virulent characters which it presented; and there can be equally little doubt that, as Dr. Scot observed, had the number of wounded men been larger than it was, they would all have been attacked, like the other wounded, by the hospital gangrene.

In the early period of the war many of the wounded patients who were conveyed from the Crimea to the general hospitals at Scutari and Malta became subjects of a form of gangrene which was probably closely allied to true hospital gangrene. It broke out in the overcrowded sailing transports in which the wounded were too often placed close to one another in tiers between decks, without adequate ventilation, and without the dietary, hospital attendance, appliances, changes of dressings, and therefore perfect cleanliness, which the nature of their cases required; while, at the same time, there was a great amount of mechanical irritation of the wounds themselves from the movements inseparable from the situation of the patients on shipboard.

Hospital gangrene in French hospitals during the Crimean war.—Hospital gangrene, described by M. Legouest to have been contagious both mediately and immediately and by inoculation, prevailed epidemically among the wounded in the hospitals of the

French army, both in the Crimea and at Pera, as well as in the vessels which conveyed them to the latter place and to France. M. Legouest says that it was severe during the whole period of the war in the East (1854–56), its intensity having more relation to the number of patients admitted into the hospitals than to the seasons of the year. Able treatises on the disease as it appeared at this time were published by several French military surgeons. M. Legouest also remarks that it showed itself during the Italian campaign, in the spring and summer of 1859, in proportions less considerable than in the East, but still in a very lamentable degree, and that it also existed during the whole duration of the war in France in 1870–71.[10]

Hospital gangrene in India.—One of the severest visitations of hospital gangrene in an endemic form of late years in the British service occurred in India in the besieged Residency of Lucknow in 1857. Hospital gangrene attacked nearly every one who was wounded, and proved fatal to a large majority of the number. Dr. Arthur, surgeon of the 1st Madras Fusiliers, has given an instructive account of this epidemic of hospital gangrene and its apparent causes. After General Outram's arrival with the subsidiary force in September 1857, the position occupied by the troops besieged in the Residency was considerably extended. On this account the duties continued as severe as they were before the arrival of the additional troops. The numerous outposts and guards could not be relieved, and the men had to sleep at their posts. A considerable number of wounded men were added to the number already in hospital at the time the reinforcements entered. The hospital accommodation was bad, as well as the sanitary state of the garrison. Not only were the hospitals generally crowded, but some of them had to be barricaded to protect the patients from the enemy's fire. The rules of ventilation and of requisite cleanliness could not be properly enforced. Disinfectants were extremely scarce. The want of a nutritious diet and sufficient amount of stimulants, as well as of all comforts and conveniences, further lessened the chances of recovery among the patients. Few wounds consequently healed without sloughing, and many were attacked by hospital gangrene, which could only be arrested by the free application of strong nitric acid. Dr. Arthur records his belief that not one instance of a successful case of amputation of the thigh or leg occurred throughout the siege. Many cases appeared to progress favourably for four or five days, and even partial adhesion would take place; the patient would then probably have a rigor or two, followed by febrile excitement, thirst, and irritation of stomach; the flaps would swell open and assume a dark sloughy aspect, and the patient would speedily sink and die. Some cases of amputation of the arm succeeded, but very few even of them. Towards the termination of the siege, ampu-

tation was only performed when no hope remained without it. Sometimes a slight scratch or contusion would become a large sloughy or gangrenous wound. No wound, however simple, could at the commencement be pronounced to be without danger.[11]

Hennen's description of hospital gangrene.—Dr. Hennen observed that when premonitory symptoms usher in an attack of hospital gangrene, they resemble those which precede an attack of erysipelas, but are more aggravated in degree.[12] He has distinguished three stages of the disease; and, with regard to the first or incipient stage, he says: 'Let us suppose that our wounded have all been going on well for several days, when suddenly one of our most promising patients complains of severe pain in his head and eyes, a particular tightness about the forehead, want of sleep and loss of appetite, and these feelings are accompanied with quickness of pulse and other symptoms of fever; his wound, which had been healthy and granulating, at once becomes tumid and dry and painful, losing its florid colour, and assuming a dry and glossy coat.' According to Dr. Hennen, the disease was generally under control in this incipient stage, but if it were overlooked, then the second stage rapidly supervened. 'The febrile symptoms very soon became aggravated; the skin around the sore assumed a higher florid colour, which shortly became darker, then bluish, and last black, with a disposition to vesicate; while the rest of the limb betrayed a tendency to œdema. All these threatening appearances occurred within twenty-four hours; and at this period also, the wound, particularly if it were situated on a muscular part of the thigh, buttock, or calf of the leg, whatever might have been its original shape, soon assumed the circular form. The rapid progress and the circular form of the ulcer were highly characteristic of the hospital gangrene, and obtained almost universally in every wound infected with it, wherever situated. The discharge in this second stage became dark-coloured and fetid, and the pain was extremely poignant. The gangrene still advancing, fresh sloughs were rapidly formed, the increasing cup-like cavity of the ulcer was filled up and overtopped by them, and the erysipelatous lividity and vesication of the surrounding skin gained ground, while chains of inflamed lymphatics could be traced from the sores to the adjoining glands, there exciting inflammation and suppuration, which often formed a new nidus for gangrene. The face of the sufferer assumed a ghastly anxious appearance, his eyes became haggard and deeply tinged with bile, his tongue loaded with a brown or blackish fur, his pulse considerably sunk in strength and proportionately accelerated.' Dr. Hennen then describes at some length the remarkable impatience of pain and depression of spirits which all the patients, even the bravest soldiers, exhibited during the progress of the disease.

In the third and last stage, 'the surface of the sore was constantly covered with a bloody oozing, and, on lifting up the edge of the flabby slough, the probe was tinged with dark-coloured grumous blood, with which also its track became immediately filled; repeated and copious venous bleedings now came on, which rapidly depressed the patient still further; the sloughs, whether falling off spontaneously or detached by art, were quickly succeeded by others, and discovered on their removal small thickly studded specks of arterial blood. At length an artery sprung, which, in the attempt to secure it, most probably burst under the ligature; the tourniquet, or other pressure, if now applied, was vain, for while it checked the bleeding, it accelerated the death of the limb, which became frightfully swelled and horribly fetid. Incessant retchings soon came on, and, with coma, involuntary stools, and hiccough, closed the scene. Often, however, the patient survived this acute stage of the disease, to sink under severe irritation, absorption of putrid matter, and extensive loss of substance, without any other symptoms than those of hectic fever arising from other sources.'

Dr. Hennen's experience of hospital gangrene was principally obtained in a large military hospital near the town of Bilbao, of which he was in charge in August 1813. There were a thousand patients in the building, suffering from wounds which had mostly resulted from the battle of Vittoria. The position of the hospital, which was situated about six miles from the Bay of Biscay, and the building itself, were to all appearance exceedingly favourable for the accommodation of the patients; the weather was mild at the time the hospital gangrene first appeared; but beside the noxious agglomeration of wounded men, there were many deficiencies of needful appliances. There were no bedsteads, and Dr. Hennen remarks, 'The wounded lying on straw spread upon the floors, and very much crowded together, was one cause, no doubt, of the rapid progress of the contagion.'

Early symptoms of the disease.—It will be observed that in his description of this outbreak of hospital gangrene, Dr. Hennen places the constitutional symptoms before the changes in the wound itself. Sir James M'Grigor, whose opportunities of forming an opinion on the subject at this period were also very extensive, seems equally to have come to the conclusion that constitutional disorder preceded the local symptoms.

All observers have not agreed in these respects. Mr. Blackadder, in his remarks on the disease, which he also saw in Spain, has stated that he did not observe in any one instance the constitutional symptoms precede the local,[13] and that it was not till the third or fourth day that the constitution exhibited signs of irritation. He regarded it as a local disease *sui generis*—the result of a specific poison. Mr. Copland Hutchinson and other observers, French as well as English, have also maintained that

the disease appears first as a local affection. These discrepancies in the statements of close and experienced observers lead to the inference that there is no fixed order of procedure in the local and general phenomena of hospital gangrene. Mr. Guthrie, indeed, who had great personal experience of the disease during the Peninsular war, has asserted that sometimes the constitutional and sometimes the local symptoms take the precedence, the order varying according to climate, season, and other circumstances. His description of the appearance and progress of a wound poisoned by hospital gangrene, while equally expressive with that of Dr. Hennen, contains information on one or two points which Dr. Hennen has not noticed. 'A wound attacked by hospital gangrene in its most concentrated and active form presents a horrible aspect after the first forty-eight hours. The whole surface has become of a dark red colour, of a ragged appearance, with blood, partly coagulated and apparently half putrid, adhering at every point. The edges are everted, the cuticle separating from half to three-quarters of an inch round, with a concentric circle of inflammation extending an inch or two beyond it; the limb is usually swollen for some distance, of a shining white colour, not peculiarly sensible except in spots, the whole of it being œdematous or pasty. The pain is burning and unbearable in the part itself, whilst the extension of the disease, generally in a circular direction, may be marked from hour to hour; so that, in from another twenty-four to forty-eight hours, nearly the whole of the calf of a leg, or the muscles of a buttock, or even of the wall of the abdomen, may disappear, leaving a deep great hollow or hiatus, of the most destructive character, exhaling a peculiar stench which can never be mistaken, and spreading with a rapidity quite awful to contemplate. The great nerves and arteries appear to resist its influence longer than the muscular structures, but these at last yield; the largest nerves are destroyed, and the arteries give way, frequently closing the scene, after repeated hæmorrhages, by one which proves the last solace of the unfortunate sufferer. I have seen all the largest arteries of the extremities give way in succession, and, till the progress of the disease was arrested by proper means, the application of a ligature was useless. The joints offer little resistance; the capsular and synovial membranes are soon invaded, and the ends of the bones laid bare. The extension of the disease is, in the first instance, through the medium of the cellular structure of the body. The skin is undermined and falls in, or a painful red and soon black patch or spot is perceived, at some distance from the original mischief, preparatory to the whole becoming one mass of putridity, whilst the sufferings of the patient are extreme. A complaint of this kind cannot long be local, even if a local origin be admitted. The accompanying fever is usually dependent on the

previous state and general constitution of the patient, modified by the season of the year or the prevailing type of febrile diseases.'[14]

Such is Mr. Guthrie's description of this formidable complication, as he observed it during the war in the Peninsula. In its less virulent forms, an amendment might be observed to commence five or six days after the beginning of the attack. The pain in such an instance would become less; the discharges lose their offensive odour, and become more healthy in consistence and appearance; the turgid and dark red integument surrounding the diseased part become more bright, and assume a condition of healthy inflammation; while the wound or sore would regain its normal tendency to granulation and cicatrisation. Such a favourable change was rarely observed, however, unless the position and circumstances of the patient were altered from what they had been at the time he was first attacked.

Varieties of hospital gangrene.—Two forms of hospital gangrene have been generally recognised, viz., the ulcerative and the pulpous; the first-named being the least active and least destructive, the latter the graver form of the disease, but both forms liable to succeed each other in the same wound or sore. Some other varieties have been brought to notice by military surgeons. M. Legouest, from his observations of the disease in the French hospitals during the Crimean war, was led to describe two varieties, which he designated the gelatinous and the gelatinous hæmorrhagic: the former being named from the exudations occasionally assuming a colloid and partly translucent character; the latter, from the sanguineous infiltrations with which these colloid exudations are sometimes mingled, especially in patients of a scorbutic taint. It is chiefly in the pulpous form of hospital gangrene that the false membranes are produced which originated the name of 'wound diphtherite' for the disease. The granulations of the surface of the wound in this variety first become dull and turgid in appearance, and are then covered by a layer of whitish-grey or ash-coloured exudation with dark points, and a characteristic odour of tainted meat. The exudation quickly increases in thickness and consistence; the disease thus differing from what has been described as the ulcerous form, in which there is no other covering than a sanious discharge. This membranous coating is strongly adherent to the granulations beneath; it can in some instances be peeled off them like a diphtheritic membrane, though not without giving rise to oozing of blood from their surface. When this coating has acquired a certain thickness, it softens down, becomes putrid, dark in colour, and emits a horribly fetid odour. At the same time the gangrene burrows and extends itself in the areolar tissue, while other structures in the neighbourhood become more or less implicated in the morbific process. Each variety of the disease is accompanied with intense local pain.

Different symptoms of hospital gangrene and simple gangrene.—Hospital gangrene differs in several respects from the complication of simple gangrene elsewhere described. The manner in which it attacks a wound, and the remarkable rapidity with which it destroys the integrity of the surrounding structures, more particularly the connective tissue ; its capability of propagation from person to person ; the circular outline which the diseased action generally assumes as it spreads superficially ; its nauseous odour, almost characteristic of the disease ; the severity of the attendant pain ; its special effects on certain structures, such as its invasion of arteries without causing thrombosis—these are all circumstances which cause it to fall within a distinctly separate category from ordinary gangrene.

Various modes of origin attributed to hospital gangrene.—The majority of the surgeons who have recorded their experience of hospital gangrene have regarded it as the result of a local poison. That it was due to a special virus they considered to be established by the fact that the gangrene might be communicated to a wound in a healing condition in a patient of good constitution and good general health, by the direct contact of sponges, charpie, bandages, lint, and other articles, which had been impregnated with the discharges from another wound affected with the disease. In like manner a slight wound or abrasion in the hand of a surgeon might become infected with the disease through touching a wound which had been attacked by hospital gangrene ; or a puncture by an instrument soiled with the matter discharged from such a wound would propagate its kind, even though efforts might be made to escape from its noxious effects, not only by local treatment, but also by going away to a situation where the air was of the purest character.

In the year 1810, M. A. F. Olivier of Paris allowed himself to be inoculated in the right arm with matter from a case of hospital gangrene. He was in good health, and went into a pure atmosphere away from the neighbourhood where hospital gangrene was existing. By the fifth day the part had assumed all the characteristic features of hospital gangrene, when M. Olivier interrupted the progress of the sore by removing the sloughs and applying strong nitrate of silver. Assistant-Surgeon Blackadder became the subject of it by accidentally puncturing himself in one of his fingers while examining the stump of a patient who had died from the effects of the disease. M. Legouest also mentions that several of his subordinates contracted the disease in the East in consequence of pricking their fingers with pins while fastening the dressings of the wounded.[15] Mr. Holmes Coote has mentioned that during an outbreak of hospital gangrene which took place in the year 1846 in St. Bartholomew's Hospital, 'the extension of the disease was clearly traced in two instances to the

use of a sponge which had been first applied to a gangrenous sore, then boiled, and afterwards applied to a healthy wound.[16] Thus subjection of the sponge to the temperature of boiling water did not suffice to destroy the *materies morbi* contained in it. This fact agrees with the results of repeated experiments on the subject.

A striking illustration of the communication of the disease by contact, as well as of the necessity of rigid surgical cleanliness on the part of those who have to deal with it, as it occurred at Bonn during the war (1870–71) between France and Germany, was mentioned by Mr. A. E. Barker in a paper read before the Surgical Society of Ireland in 1873.[17] The gangrene only manifested itself among the patients of one particular surgeon, whose dressers, as Mr. Barker considerately remarked, could not be said to be of cleanly habits. In the case of one patient who had arrived at Bonn with a perfectly clean-looking amputation wound of the thigh, a ligature, which was still adherent to a large artery on the inner aspect of the stump, was removed, and the hospital gangrene commenced distinctly at that spot. 'In this case the thread was removed by the surgeon in attendance on the other cases of gangrene, whose hands may have conveyed the poison, whatever it be.' The cases attacked were 'lying in a room with about ninety other wounded men, and yet only those subjected to the manipulations of one set of dressers were attacked.'

Some facts have tended to show that the poison of hospital gangrene may be communicated by the specific emanations from wounds affected with the disease floating in the atmosphere. This would be as truly a local application as if the poison were applied by the direct application of some of the discharge on a sponge or piece of charpie. A notable instance of this nature has been mentioned by Dr. Hennen.[18] It is mentioned by him in the following words: 'At the end of the summer of 1798, in a French military hospital at Leyden, hospital gangrene prevailed in one of the low wards, whilst the patients who had slight wounds, and were placed above this ward in a well-aired garret, were found to escape the disease. The surgeon judged it necessary to make an opening in the floor of the upper room, in order by that means to afford an outlet through the roof to the air of the infected ward below. Thirty hours afterwards three patients who lay next to the opening were attacked by the disease, which soon spread through the whole ward.' In this instance the position of the patients who were first attacked, the rapidity with which the gangrene followed the opening of communication with the infected ward, and the concurrent appearance of the disease in several patients, appear to leave little room for doubt that the diseased action was induced by the topical effects of the air, or rather of specific emanations from the wounds affected by hospital gangrene carried upwards by it as it rose from the ward below.

Mr. Blackadder was a strong believer in the contagious character of hospital gangrene. He asserted that, so far as he had had an opportunity of observing, ninety-nine cases in the hundred were evidently produced by a direct application of the morbific matter to wounds through the medium of sponges, tow, water, instruments, and dressers; and he adduced some remarkable illustrations of the escape from the disease of wounded patients in beds adjoining those in which other patients with hospital gangrene were lying, when rigid measures were taken to prevent all direct contact between them.[19]

It will be noticed that the conviction of many of the older surgeons that hospital gangrene depended mainly on the presence of a local poison, and all the facts adduced by them in support of this belief, are quite consistent with the modern views of specific micrococci found in the diseased tissues being the generators of a poisonous fermentation, the product of which fermentation constitutes an essential element of this disorder, and gives it its malignant character.

Hospital gangrene during the United States Civil War.—Observations on hospital gangrene are recorded at considerable length in the Surgical History of the United States War, as it was then witnessed in the military hospitals. The remarks on the disease sufficiently show that while in the majority of cases it was due to direct infection, in some instances it was undoubtedly independent of it, and of indigenous origin. A very full and careful report by Surgeon Goldsmith, U.S.V., illustrative of the latter mode of origin, is quoted in the history. He had been sent to investigate an outbreak of the disease at Nashville. In one hospital there, thirty-eight cases of hospital gangrene had occurred, and they all took place in one ward, in a particular row of beds near to certain windows which opened upon a confined alley. Surgeon Goldsmith succeeded in tracing out the fact that the patients affected had been exposed to air entering through these windows, which had been opened for ventilation. This air was foul, and loaded with miasmata which had been generated by putrefying animal and vegetable matters in an area and cellar outside, and situated beneath the windows. All the cases occurred when the external atmosphere, being colder than the air of the ward, which was artificially heated, would naturally enter the ward forcibly; while no cases occurred after the weather grew so warm that the temperature of the outer air was higher than that of the air within the building.[20]

Conditions which favour the development of hospital gangrene.—Military experience has sufficiently established the fact that there are certain conditions which generate a predisposition to hospital gangrene, and materially assist in its dissemination when once it is established.

In all the instances in which hospital gangrene has appeared in a virulent epidemic form, there has been, at the beginning, too great a number of wounded men with sloughing and suppurating wounds in respect to the space in which they have been accommodated. This serious evil cannot always be avoided under the accidents of military operations; but formerly it seems to have been the rule, instead of the exception, in military hospitals. It is this circumstance which caused hospital gangrene to attract so much notice in connection with military practice. There have been civil hospitals within comparatively recent times which were never wholly free from hospital gangrene owing to original faulty construction, defective drainage, and to a bad position among a dense population; but, from the relatively limited numbers of wounds in these buildings, the disease did not assume such a virulent epidemic character as it has from time to time exhibited in military hospitals in time of war.

The situation of a hospital on low flat ground near a river, or in a marshy district, has sometimes appeared to act as a predisposing cause of hospital gangrene, and to excite a proneness on the part of the patients to be attacked by it. After the battle of Waterloo the disease prevailed much more at Antwerp, the situation of which is very low, than at Brussels, which is comparatively high. All the worst cases at Brussels were in the old or lower part of the town. The disease assumed an intense form in a hospital about two miles from Brussels, where the Brunswickers were treated: nearly every patient on whom amputation was performed died from it. This hospital was situated on a thickly-wooded swampy flat, through which the great Antwerp canal was cut.[21] The only outbreak that occurred in the Crimea took place in a hospital, the surgeon in charge of which, as before mentioned, attributed the disease in a great measure to the confined position and undrained soil on which the hospital was placed.

The position of the wards in which the patients are under treatment has also seemed to exert an influence on the tendency to the disease. It has been noticed that outbreaks of hospital gangrene have usually commenced in the lowest rooms of the building in which the wounded have been collected. This might be attributable to the fact of these being the rooms in which there is least movement of air, owing to the obstruction of walls, streets, and adjoining buildings; while they are the most exposed to the reception of effluvia from the surface of the ground, from privies, and other such sources of contamination.

A high degree of temperature has seemed to favour the appearance and spread of hospital gangrene, though it may occur at all seasons of the year. The worst epidemics recorded by British surgeons have taken place in fixed hospitals

during the heat of summer. When the high temperature is combined with dampness of soil and a still atmosphere, overcrowding, and other unsanitary conditions, the circumstances are still more favourable to the development of the disease. In open campaigning in tropical climates, where the field arrangements have generally admitted of so much wider a distribution of patients in tents or comparatively open bungalows, hospital gangrene in an epidemic form has been rare. But under other circumstances, when troops have been closely confined, as they were at Lucknow in 1857, or when the wounded have been placed in considerable numbers in walled hospitals near native habitations, it has been largely disseminated and has assumed a most virulent form in India.

There seems to be no doubt that all causes which depress the spirits of soldiers predispose to hospital gangrene, as they do to other diseases of a similar type. It was observed after the battle of Waterloo that the despondency resulting from defeat caused the spread of hospital gangrene, and the number of deaths resulting from it, to be greater among the French prisoners than among the British wounded at Antwerp. The bodily fatigue and pain endured by wounded soldiers who have been subjected to long transport in wheeled conveyances, as well as the injury often done to the wounds themselves by the movement, must also be taken into account among the other causes which have predisposed to the occurrence of this disease in military hospitals.

The same facts were illustrated during the United States war. Hospital gangrene prevailed to a serious extent in some bodies of paroled prisoners who had been brought from Richmond to Annapolis. They had been closely confined in the prisons and prison hospitals, and the circumstances of their imprisonment were of a nature to depress the men morally and physically. Some of the prisoners who had been taken on western battle-fields referred the development of the disease to their tedious and painful transportation from the West to Richmond.[22]

CHAPTER V

PYÆMIA AFTER GUNSHOT WOUNDS

General remarks.—A large proportion of the deaths from gunshot wounds in all recent large wars, from the Crimean war to the war in France of 1870–71, has been ascribed in military professional returns to pyæmia. This source of mortality was not

mentioned in the Peninsular or Waterloo returns. Pyæmia may be defined to be a systemic septic disease of very fatal character, generally supervening on a suppurating wound, and usually marked by fever of a remittent type, and the formation of abscesses in various parts of the body and viscera at a distance from the wound itself. The constant presence of certain forms of microbes, pyogenic cocci, not only in the pus of the primary suppurating wound, but also in the distant or metastatic abscesses so characteristic of the disease, has been demonstrated by pathologists; but unfortunately this knowledge has not yet afforded the means of averting the generally fatal issue which attends it when once the disorder has been fully established. It is hoped that this desirable end may be eventually attained. In the meantime the prevention of its occurrence among wounded patients in field hospitals is the practical point to which the attention of army medical officers may most advantageously be directed.

Occurrence of remote abscesses after wounds.—The development of abscesses in parts of the body at a distance from some particular spot in which suppuration had occurred after an injury, had long been known, and is occasionally referred to in the works of very early writers. The occurrence was explained by those who adopted the humoral views on the nature of disease as a translation of the puriform matter itself from the place it had previously occupied to its new situation; while those who referred diseases chiefly to alterations of the solid parts of the body, attributed it to transference of the irritative action which had originally produced the morbific matter. The particular channel along which the puriform fluid, or the irritative action, was conveyed was not attempted to be explained; the distant abscess was simply described as a change in the seat of the disease, and hence the term then employed of 'abscess by metastasis.' This doctrine was opposed by John Hunter. In his work on the 'Blood, &c.,' he strongly repudiated the possibility of a quantity of pus being carried or transferred from one part of the body to another.[23] As examinations after death became more frequent and more carefully instituted, the occasional existence of scattered deposits of pus in joints, in some of the principal viscera of the abdomen, and into the serous cavities, especially after gunshot wounds of the extremities and amputations, gradually attracted more particular attention. Mr. Guthrie, in his 'Commentaries on the Surgery of the Peninsular War,' ascribed their occurrence to the effects of phlebitis, and claimed to be the first who had pointed out the intimate relationship between this disorder and the secondary deposits referred to. Baron Larrey noticed the occasional formation of abscesses in the liver after injuries to the bones of the upper and lower extremities, but more especially after gunshot wounds of the head. Dr. Esmarch, in his 'Treatise on Resection

in Gunshot Injuries,' founded on observations in the Schleswig-Holstein campaigns, where pyæmia was of frequent occurrence, has remarked: 'We generally found the cause of pyæmia to be inflammation of the veins. It is especially from the veins of the bones that this infection proceeds,' &c. Dr. Stromeyer, who was surgeon-in-chief of the Schleswig-Holstein army in the campaign of 1849, remarks in his 'Treatise on Fractures of Bones from Gunshot': 'I have many times convinced myself that the pus first passes into the larger veins out of the osseous substance, and thence reaches the general circulation.' Pyæmia is recorded in the British official report of the surgery of the Crimean campaign as having been a frequent cause of death; but instead of being attributed to the effects of phlebitis, it is stated that, though secondary purulent deposits were far from an uncommon accompaniment of pyæmia, post-mortem examinations rarely revealed any inflammation of the venous canals, and when any evidence of such inflammation was found, it usually consisted of the exudation of more or less perfectly organised lymph. In exceptional cases, when the formation of pus had actually taken place within the canal of a blood-vessel, the matter was mostly isolated and cut off from communication with the blood by a deposit of plastic material around it. The greater number of French surgeons appear to have regarded pyæmia, or, as it was more frequently called by them, 'purulent infection,' both in the Crimean and in the subsequent Italian war, as a result of the secretion of pus in the veins, and its mixture with the blood in circulation. We may thus trace the successive steps by which the conviction was at last arrived at, that the absorption of septic pus in the blood is the active agent in the production of the disease, and that thrombosis and embolism, consequent on the infection, are the direct precursors of the local abscesses which attend it. According to the researches of Dr. Robert Koch and other experimentalists, the entrance and growth of particular micro-organisms which find a favourable soil for their development in a suppurating wound, while increasing the local suppurative action, confer on the pus the special septic qualities which lead, when it has entered the venous circulation, to the formation of thrombi, themselves tainted, and to the other morbid consequences of the disease.

Mortality from pyæmia among the wounded in Paris in 1870–71.—The proportion of deaths from pyæmia during the siege of Paris was unusually great. Surgeon Macdowall, of the Indian Army Medical Service, who acted as a volunteer surgeon in the French hospitals during the whole of the siege, has recorded that 'the mortality from pyæmia and hospital gangrene amongst the wounded and amputated is known to have been greater than has ever occurred before in the annals of military surgery.' And again, 'Pyæmia was the almost universal cause of death in the

wounded, and was so without exception in amputations, even at the American tent ambulance, where the treatment was almost open-air treatment.' Dr. Demarquay, one of the most distinguished surgeons and men of science in Paris, told Surgeon Macdowall that 'he had not succeeded in saving a single case of amputation at the newly planned and constructed wood-hut hospital at Passy.' The eminent Dr. Ricord described the ravages of pyæmia in this hospital, large and well ventilated as it was, as fearful. This scourge increased in severity as the duration of the siege increased. Dr. J. Worms, the Sanitary Commissioner of Paris, stated that 'in round numbers all the cases of amputation in the last few weeks of the siege died; that the result was the same with nearly all corresponding cases in which the operation was not performed; and that these deaths were almost all from purulent infection.' Surgeon-General Gordon mentions in his report on military surgery during the siege of Paris: 'The prevalence of purulent infection increased as the siege went on, and the wounds became more numerous; also, it must be observed, as the fatigue, exhaustion, and the moral effects of repeated want of success became more and more pronounced.' Surgeon-Major Wyatt also, in his report on the siege, writes of the constant prevalence of purulent infection, and of the usually fatal issue of the disease.

Wounds specially liable to pyæmia.—Any wound in which the process of suppuration is going on, especially if it be exposed to prolonged exposure to tainted air or any source of impurity, seems to be capable of inducing pyæmia; but certain species of wounds seem to be more liable to it than others. Gunshot fractures of bones in which great comminution has occurred; wounds of veins; amputations of limbs through the shafts of bones opening their medullary cavities, particularly if the operation is performed when the medullary membrane is in an inflamed state; and wounds of the head in which the cranium is implicated, especially when such wounds occur in men whose strength has been reduced by hæmorrhage or other depressing circumstances—appear to present conditions more favourable for the development of pyæmia than simple flesh wounds, removal of portions of limbs through joints, or wounds of the chest or abdomen. On the other hand, the occurrence of pyæmia has been noted after a mere gunshot erosion—the general infection, with its manifestations of metastatic deposits and the other characteristic signs of the disease, originating to all appearance in this so apparently trifling wound. Cases of pyæmia have even been reported in which no wound or abrasion has been detected—idiopathic pyæmia.

Symptoms of pyæmia.—The symptoms of pyæmia are by no means uniform, and the period at which the disorder may arise after an injury is also very uncertain. The symptoms may appear shortly after suppuration has been established, but in military

practice it has been more commonly met with in the later stages of wounds. The subject of pyæmia, who may have apparently been progressing quite favourably and feeling confident of recovery, is generally seized with an attack of shivering. This takes place, perhaps, after a disturbed and restless night. Alternate chills and febrile heat follow, with excessive perspirations, headache, great exhaustion, and general aching and uneasiness. All appetite for food is lost. The patient's countenance becomes very anxious, his spirits are depressed, and he becomes despondent about the issue of his wounds. He may be observed to turn about frequently; his pulse is rapid, irregular, but generally readily compressible; the skin is sallow, of a dusky, jaundiced hue, and sodden from the profuse sweating. His breath has a peculiar odour, which hardly admits of correct description, but which, once smelt, is readily recognised again. The parts adjoining his wound assume an unhealthy œdematous appearance. If the suppuration has been previously healthy in character, the discharge becomes thin and ichorous, and is deficient in quantity; or the wound may seem to be stationary, so that its surface becomes dry. The edges of the wound usually exhibit a flabby half-dead appearance, and have a tendency to gape; the skin immediately surrounding it is probably injected and turgid. The temperature is high. Perhaps commencing inflammation in some of the serous membranes may now be observed, either over the brain or in the chest or abdomen; or the usual symptoms of effusion may be indicated, with scarcely any trace of local inflammatory action preceding the appearance of the collected fluid. Or the patient may suddenly complain of pain like that of rheumatism in one or more joints, which rapidly become swollen, perhaps red on their surfaces, and exhibit the characteristic features of fluid effusion into their synovial cavities. In some joints the appearances may be those of simple synovitis, in others those of suppurative inflammation. There may be fulness and tenderness on pressure in the hepatic region; or disordered respiration, dyspnœa, cough, and other signs usually indicative of sub-acute lobular pneumonia, may be the most marked symptoms presented. In one case at Fort Pitt I saw the globes of both eyes rapidly destroyed by suppuration. Again, there may be dark bilious purging, or there may be copious discharges from the bowels of a serous or mucous character without much admixture of bile, according as the liver or bowels are the parts to which the excess of action is determined. As the disease advances, the features become pinched, and strikingly rapid emaciation attracts notice; there is probably diarrhœa; profuse perspirations, increased exhaustion and debility follow; no sleep can be induced; and finally, stupor, delirium, and other typhoid symptoms announce the close approach of the fatal termination.

Re-separation of united gunshot fractures from pyæmia.—

Another mode in which the effects of pyæmia may be occasionally exhibited in military hospitals is the following. A case of gunshot fracture of the shaft of a bone may have been progressing favourably, a considerable quantity of callus may have been thrown out and consolidation to a great extent effected, when suddenly pyæmia supervenes, and all this advance towards union recedes, the ends of the broken bone again become detached and loose, and a fatal result follows. A striking instance of this retrograde action, consequent upon a sub-acute form of pyæmia, came under my notice in the Crimea.

Corporal B., 19th Regiment, aged 19 years, of good health and strong frame, had his left thigh-bone comminuted at the attack on the Redan on the 8th September 1855 by a rifle bullet. The missile struck the shaft near its centre. The bone was much split, and amputation, if performed, would have had to be done close to the trochanters. In consequence of the very unfavourable results which had attended amputations in this situation, and considering the youth and good constitution of the patient, I determined to try and save the limb. The case progressed favourably for some time. Some dependent incisions had to be made to facilitate the escape of pus and to effect the removal of detached splinters. At the end of October consolidation had so far advanced that the patient was able unassisted to raise the limb a short distance up from his bed. On the 2nd November, however, without any apparent cause, he was seized with rigors and vomiting; profuse bilious diarrhœa followed, and, though checked for a time, continued to recur at intervals up to the date of his death. The discharge from the wound became excessive in quantity, of thin consistence, dark colour, and offensive; there was the peculiar odour of pyæmia; the ends of the bone at the seat of fracture became loose and movable; the patient very despondent; he had a quick, small pulse, and suffered from chills, followed by fever and profuse night-sweats, as if he were suffering from a complication of ague, of which, however, there was no previous history. Then great œdema of the injured extremity appeared, with excessive general prostration, and the patient expired on the 1st of December.

Attempts were made, by the free use of stimulants and appropriate medicines, to bring the patient's constitution into a state offering a favourable prospect for secondary amputation of the limb, but without success. At the post-mortem examination, all the muscles of the thigh presented a peculiarly pale, œdematous, almost gelatinous aspect; the structures around the seat of fracture, and for some distance from it, upwards and downwards, were in a semi-sloughy, softened condition; and the connective tissue of the whole limb was infiltrated with ill-conditioned purulent fluid, without any apparent effort to circumscribe it.

Dr. Esmarch records an acute case very similar in its results. A Schleswig-Holstein soldier had both his left femur and left humerus shattered by musket bullets. At first the case proceeded favourably, and the humerus was consolidated in the third week without the removal of a single sequestrum. The femur also seemed inclined to heal, although the bullet remained in the wound; but, in the fourth week, the discharge became sanious. Pyæmia developed itself from this time, and soon proved fatal. During the last few days the fracture of the humerus again gave way. At the autopsy, it was found that this bone, in its middle, was in eight large splinters, of which five were already firmly united to the lower, and three to the upper fragment, by means of a considerable mass of callus. This callus was evidently reabsorbed at the spot where the splinters had been mutually united, and thus the continuity had been again broken.

Modes of death in pyæmia.—When pyæmia runs on to a fatal termination, and this is its usual result within a period of four to eight days, death may occur in several ways. It may either happen from cerebral excitement, succeeded by coma; or the patient may sink under the effects of various visceral disorders. In some instances fatal pneumonia, gangrene of the lungs, or empyema have supervened. Death may take place rapidly by paralysis of the nervous centres, or under symptoms of fever of a typhoid character; or, where the pyæmic abscesses are so placed as not to interfere seriously with the more important vital functions, the patient may sink more slowly from general exhaustion, or the effects of excessive diarrhœa.

Nature of pyæmia.—The complex symptoms which characterise pyæmia have led to a great variety of theories for their explanation. The term pyæmia, or pus-poisoning of the blood, sufficiently shows the opinion which originally dictated it. No one now believes that true pus, in its uncorrupted state, can be absorbed into the circulation and be the source of the symptoms which accompany pyæmia. Like the doctrine of metastasis, or change of seat of pus from place to place, as once held, the notion of pus circulating through the circulatory system in this disease is now abandoned. By most pathologists the disease is attributed to the invasion and growth of pyogenic microbes. The manner in which pyæmia may be communicated from patient to patient by using the same sponges or materials of dressings, its tendency to prevail in buildings which have been previously for some time in use as hospitals for the treatment of wounded, and many other such circumstances, favour the idea of infection by some form of septic poison or nosogenic micro-organisms.

One of the most frequent phenomena accompanying pyæmic disease is the formation of clots or thrombi, probably septic, in some of the veins. The detachment of fragments of these clots,

carriage of them into the general circulation, and their subsequent impaction at some parts of the circulatory system where the arteries become too small to admit the clots to pass on, lead to the phenomena of embolism. The obstruction of the vessel by the clot or embolus leads to the deprivation of a particular part of the body of some of its normal supply of blood; inflammation of a low type or septic character is excited, a pyæmic abscess is formed, or occasionally gangrene results. Thrombosis and embolism thus together become leading causes in the production of the purulent collections which constitute some of the most remarkable features in the pathology of pyæmia.

But the purulent collections which are met with in pyæmia cannot always be traced to the origins just named. Sometimes they take place with a rapidity and in such a diffuse way as to exclude embolism from being concerned in their production. Several joints remote from each other may become tender and swollen together, or may become enlarged without attracting early attention, proving there has not been much pain, and in a few days may be filled with fluid of a purulent character. Diffused collections of sero-purulent fluid may with almost equal suddenness spread through the connective tissue of one or more limbs, or may accumulate in one or both of the pleural cavities. Multiple abscesses may form in the liver or lungs, and yet no signs of embolic mischief be traceable in these organs. The fact than an embolic source is not discoverable is not of course a sufficient proof that no such origin has existed; but the absence of the appearances of embolism that are occasionally found elsewhere, and particularly the rapidity with which these collections sometimes form, certainly favours the supposition that they are occasionally formed independent of any such origin. In some of these instances the infection appears so suddenly, and is so general in its nature, that those who regard microscopic germs as the essential cause of the disease, attribute it to the action of certain microbes that are able to penetrate all the living tissues, to grow and multiply in them as well as in the blood, and so to give these pyæmic cases their virulent character. Judging, however, from clinical observation of them, it seems impossible to exclude at the same time the existence of special degrees of receptivity in different individuals, traceable either to constitutional peculiarities, previous habits of life, the extent to which men have been subjected to unhygienic surroundings, to excessive fatigue from prolonged marches or other military operations in which they have been engaged, or to some other such causes giving various degrees of predisposition to the disease.

Association of pyæmia with gunshot wounds of bones.—There appear to be several reasons why pyæmic action is more likely to follow gunshot wounds of bones than injuries of other

parts. The prolonged duration of the suppurative action while sequestra are being detached, and the formation of new bone is proceeding; the long period of confinement in a hospital atmosphere to which the patient is necessarily subjected; the frequency with which an extension of the suppurating action takes place along the medullary canal; the obstructions which are apt to cause imprisonment of the pus, so that its constant free escape is not permitted, as in wounds of the softer parts; the facility which is gradually acquired for the pus to burrow along and between the inactive muscles, so leading to its being retained among them for long periods; the readiness with which pus becomes the subject of putrefactive changes when air, particularly foul air, has access to it; these seem to constitute a sufficient set of causes leading to pyæmic poisoning after such injuries. The peculiar circumstances of the venous system in bones, especially the situation of the vessels in unyielding hard canals, so that their extremities after division are apt to remain patulous, seem also to favour its occurrence. Septic puriform fluid, detached particles of disintegrating tissues, and putrefactive discharges are more likely to pass along them into the general circulation, than they are along veins of the soft parts, which may collapse, or become closed by pressure from surrounding structures, after similar gunshot injuries. But in all such cases clots are usually found in veins in varying states of firmness or partial disintegration. After wounds of the head in which the vascular system of the diploë is involved, the formation of thrombi in the sinuses of the dura mater may be expected; and in case of this occurring, as the thrombi soften down, or as portions of them become detached, the particles would readily pass to the right side of the heart, and so to the finer ramifications of the pulmonary arteries. The stretched condition of the sinuses between the membranous laminæ of the inelastic dura mater causes them to correspond with veins of bones in respect to their persistent patulous condition. When pyæmia follows injuries of the head, the pyæmic foci are almost invariably found in the structure of the lungs, and this would seem to be a result of the facts just mentioned.

Prevalence of pyæmia in military hospitals.—There is this peculiarity connected with gunshot wounds in military hospitals in time of war, that usually many such wounds (and a large proportion of them are always complicated with fractured bones) occur at the same time. Hence a ward may be filled with cases in all of which suppurative action is proceeding. Under such circumstances a condition of atmosphere is easily produced that must tend to poison the constitutions of the patients. Septicæmia, varying in degree according to the amount of concentration of the putrid emanations in the atmosphere, is the result. The depraved state of the patient's blood causes the pus of a suppurating wound to

contain within itself the elements of more speedy decay. Its proneness to putrefaction is increased. This disposition of the discharges to take on the process of decomposition at once finds agents ready to set it in action in the micro-organisms abounding in the impure atmosphere if the wounds are allowed to be brought into contact with it. It has been well established that if one patient suffering from pyæmia is placed in a ward where there are many other patients with suppurating wounds, a considerable proportion of the latter will almost certainly become infected with the disease. It has also been remarked that when patients with fresh wounds are admitted into hospitals which had been used for the wounded from previous battles, especially if any patients with suppurating wounds still remain in them, the new-comers become much more than ordinarily exposed to an invasion of pyæmia. This can only be accounted for by supposing the hospital to be tainted by matters in a more or less advanced state of decomposition, concealed in the walls, floors, and ward furniture, or, according to present views, by the special forms of bacteria which belong to pyæmic infection. It must also be remembered that any circumstances tending to irritate a suppurating wound (and suppurating wounds in which the jagged ends or splinters of broken bones are implicated are particularly liable to be so irritated) have long been supposed to assist in inducing the development of pyæmia. Irritation of this kind is sure to occur when wounded men have to be transported long distances, as must often happen in time of war.

It is indeed almost impracticable, under the ordinary circumstances of warfare, to procure the absolute rest necessary for patients with fractured bones; or, with deficient numbers of surgeons and attendants in proportion to the numbers of patients, to obtain that perfection in sanitary arrangements which is essential for averting the causes which tend to the development of pyæmia. No one who is familiar with the usual state of hospitals, especially of the temporary field hospitals, and with the difficulties in the way of ensuring the requisite cleanliness of patients, attendants, and hospital surroundings, in a country where military operations are in progress, can be surprised at the frequent occurrence of septic disease among men under treatment for suppurating gunshot wounds.

Conclusions regarding pyæmia in military practice.—To judge from observation in military practice, it would seem as if, as a general rule, it were necessary for two conditions to co-exist for the development of pyæmia—viz., the process of suppuration in the patient, and the presence of an agent such as a septic poison in the atmosphere in which the patient is placed. If a patient suffering from an ailment or injury unattended with suppuration be placed in a ward in which many suppurating wounds

are under treatment, he may possibly become affected with typhoid symptoms, or some other form of septicæmia, but it is not likely he will become the subject of secondary pyæmic abscesses; and again, if a patient with a suppurating wound, however tedious and prolonged in its process, be placed, either by himself or only with patients suffering from internal diseases, in a pure and well-ventilated ward, the occurrence of pyæmia becomes an equally improbable event. It does occur occasionally under such circumstances, and sometimes where we might least expect it, in isolated cases and in private dwellings where cleanliness and ventilation appear to be fully provided; but probably, if the conditions of such cases could be thoroughly ascertained, there would be found something defective in one or other of the following respects: either the apartment has been made nearly air-tight, or what is called free from draughts and comfortable, especially at night, and in this condition has been pervaded by some source of infection; or pus has been retained, and if not actually decomposed, has become vitiated; or some neglect as to the surgical purity of the things brought into contact with the patient has occurred, so that the wound has been rendered unhealthy, with the effect of poisoning the patient.

The prognosis in regard to pyæmia, when it occurs in military hospitals in the field, is unfavourable in the extreme. It is one of the most fatal of all the complications to which wounds not otherwise of a fatal character are liable in military practice. Indeed, when pyæmia is thoroughly manifested, it is doubtful whether it is ever checked in its deadly advance. In cases where the signs of pyæmia exhibited are comparatively slight, where rather a tendency towards the affection is shown than the affection itself, or where it assumes a chronic form, no doubt, on appropriate measures being adopted, restoration to a healthy condition is from time to time witnessed. The full development of the poisonous influence appears to be arrested in these exceptional cases. But under the too frequently unfavourable conditions of hospitals in time of war, the occurrence of well-marked pyæmia supervening on a gunshot wound can be hardly regarded otherwise than as sealing the fate of the patient.

CHAPTER VI

TETANUS AFTER GUNSHOT WOUNDS

General remarks.—This is probably the most harrowing to witness of all the complications with which a gunshot wound may be attended. Few patients survive in whom this morbid condition, especially in its acute form, is thoroughly established; and, irre-

spective of the consciousness of the little power that surgical art possesses to control the agonising paroxysms which attend it, it is all the more distressing to contemplate, because even in the most violent forms of the disease the intellect of the patient usually remains perfectly clear almost to the end.

The term 'tetanus' in army nomenclature is not limited to contraction and rigidity of the voluntary muscles of the whole body, but also includes the more strongly marked local manifestations of the disorder: *trismus*, or rigidity of the elevator muscles of the lower jaw, usually observed in all cases, and in a few exceptional instances not proceeding further; *opisthotonos*, or spasmodic contraction of the extensor muscles; *emprosthotonos*, of the flexor muscles; and *pleurosthotonos*, of the lateral muscles of the trunk. Cases of the two forms last named, especially the last, have been but rarely recorded. Larrey's large experience of traumatic tetanus in his numerous campaigns led him to conclude that, when the wounds which are followed by this disease affect nerves of the anterior region of the body, emprosthotonos takes place; if the lesion implicates nerves of the posterior parts of the body, opisthotonos occurs; if the wound involves both anterior and posterior parts, general tetanus is the result. Although, however, one or other of these forms of spasm may assume greatest prominence, the disease is generally attended with contractions, of greater or less intensity, of all the voluntary muscles of the body.

Tetanus more frequent in former than in recent wars.—Military surgical histories sufficiently show that formerly tetanus followed gunshot wounds far more frequently than it has done in the wars of recent years. Reliable numerical data are not available, however, to show what the exact amount of difference has been in this respect. The difficulty in arriving at precise information on the subject arises from the fact before referred to, that the numerical returns employed in time of war show the injuries for which patients are admitted into the hospitals, but not the immediate causes of death when the cases terminate fatally. The occurrence of tetanus, as of other complications, is only made known when special observations are published on the subject; and every one acquainted with the difficulties of writing professional reports under the numerous urgent calls which occupy the time of medical officers in the field, will readily understand why more precise information on the subject is not forthcoming.

War statistics regarding tetanus.—Some examples may be quoted which will sufficiently indicate the relative immunity from tetanus in wars of late years, as compared with what took place at periods not very long removed from us.

Sir Gilbert Blane has stated in his work on 'Diseases of Seamen,' that on the occasion of the victory of Admiral Rodney in

the West Indies in April 1782, out of 544 wounded men treated on board ship or in hospitals on shore, 17 died from locked-jaw, while three others attacked by it recovered. We thus have 1 in 27 wounded attacked by the disease.[24] The number of deaths among the wounded treated on board ship or in hospitals on shore was 88. Nearly 1 in every 5 of these deaths was due to tetanus.

The proportion in which tetanus occurred during the Peninsular campaigns has not been anywhere stated with precision; but from the sketch of the medical history of the British armies during the war by Sir James M'Grigor, it may be inferred that the number of cases was very large. 'This very formidable disease,' Sir James wrote, 'has always been prevalent among the wounded after the great battles;'[25] and farther on he refers to 'several hundred cases' having been detailed.

Sir G. Ballingall, in the year 1838, published a calculation that the number of tetanic cases amongst the wounded of armies was about 1 in 79; and he sufficiently showed that tetanus in a severe form was intended by him in this remark by adding that 'the proportion of recoveries is so small as scarcely to admit of calculation.'[26]

A striking contrast with the estimate of Sir G. Ballingall is presented when the number of cases of tetanus among the wounded in the wars and conflicts which have occurred since the date at which he made his calculation is regarded. There do not appear to have been any cases of tetanus among the large number of gunshot wounds which were treated in the hospitals of Paris on the occasion of the insurrectionary outbreak of 1848; at any rate, there was not a sufficient number to attract notice. The subject of tetanus was hardly alluded to in the various discussions which took place at the time in the National Academy of Medicine at Paris on the wounds which had resulted from the conflicts. M. Roux, who had charge of a large number of the wounded at the Hôtel-Dieu, into which hospital alone 451 cases of wounds were admitted, mentioned he had not had one patient affected with tetanus to treat.[27]

During the Crimean war, which lasted nearly a year and a half, only 24 cases of tetanus among British troops supervened on gunshot injuries[28]—21 in the Crimea, and 3 at Scutari. This number amounts to 1 case of tetanus in every 479 wounded, or 0·2 per cent. M. Scrive mentions that out of 37,537 wounded men treated in the French ambulances, there were not more than 30 cases of tetanus. They all terminated fatally.[29] These figures show only 1 case of tetanus in 1251 cases of wounds, or a little under ·008 per cent. And Pirogoff has recorded that, after many inquiries, he could only get information of 5 cases of traumatic tetanus in the Russian army throughout the entire

war,[30] indicating a much less percentage of the disease than occurred in the French army.

During the Italian campaign of 1859, Dr. Chenu states, 153 cases of traumatic tetanus and simple trismus were treated in the hospitals. These seem to include all the cases that occurred among the wounded Austrian prisoners, as well as among the French wounded. He adds that he can only find one case of tetanus, well established, that was followed by cure. It is said, with regard to certain cures related in the reports of Italian surgeons, to be very doubtful whether they were instances of true tetanus. Dr. Demme, who mentions that 140 cases of tetanus came under his cognisance in the various Italian hospitals among the wounded of the three armies, says that of this number, 76 occurred in the hospitals of Brescia, but that these included cases of localised trismus and of so-called rheumatic tetanus, as well as true traumatic tetanus. A table showing the particulars of 92 cases of traumatic tetanus which occurred in the Italian campaign is printed in Dr. Demme's work. Seven recoveries are shown among the number. Of the 92 wounds preceding the appearance of tetanus, 91 were gunshot wounds, and 1 was a bayonet wound, the latter being included in the 7 recoveries.[31] Dr. Demme estimated the frequency of tetanus in the Italian hospitals at nearly 1 per cent. among the wounded.

During the war of the rebellion in the United States, among the 246,712 wounds and injuries of all kinds recorded, 505 sequences of tetanus were noted—viz., 16 among the coloured troops, and 489 among white troops.[32] These numbers give a ratio of about 1 instance of tetanus to 500 cases of injury. The greater number followed, as usual, wounds of the lower extremities, 292 instances; 137 occurred after wounds of the upper extremities; 55, of the trunk; 21 were consequent on wounds of the head, face, and neck. Of the total number, fatal results ensued in 451, recoveries in 54 instances. The rate of mortality was therefore 89·3 per cent. The complication followed closely upon amputations of the extremities in 116 cases, and upon excisions of joints in 15 cases. In 6 instances the tetanus appeared within twenty-four hours of the primary injury, and in the course of the first day also after 21 cases of amputation; in 1 instance it did not occur till seven months after the original injury. The duration of the tetanic symptoms did not exceed three days in 203 instances, and these, with 2 exceptions, all proved fatal. The longest duration of the malady among the instances which proved fatal was twenty-seven days, while among the recoveries the tetanus lasted in 1 instance for forty-nine days. An interesting case among those of which the details are given in the surgical history of the war is one of a private who was wounded in the left arm and side over the lower ribs, on 6th May 1864. Trismus and

opisthotonos appeared on May 20th. The tetanus continued, and terminated fatally on May 31st. After death, the bullet, which had entered over the ribs, was found to have passed between the abdominal muscles, then over Poupart's ligament, under the femoral vessels, and to have wounded the crural nerve, finally lodging near the middle of the thigh. The specimen of the lacerated nerve is preserved in the United States Army Medical Museum (Surg. Sect. No. 3538).

The only time that tetanus has prevailed among the wounded in British hospitals of late years has been on the occasion of the Mutiny in India in 1857. It was very prevalent both among Europeans and natives at Lucknow during the siege. Dr. Brown of the Bengal Medical Service remarks in his Notes on the Surgery of the Indian Campaign of 1857–58: 'In India tetanus is much more common than in more temperate climates, and I have little doubt that were the statistics of this campaign made out, tetanus would be found to have caused a great mortality.' [33] But very few special observations have been recorded regarding it. Dr. Brougham, in his Surgical Experience of the Siege of Delhi, does not mention tetanus as having been observed there among the wounded.

Not a single case of tetanus occurred among the British troops during the New Zealand war, between the years 1863 and 1867. The hospitals were equally free from pyæmia, hospital gangrene, and other allied diseases. All the facts mentioned in the foregoing paragraphs tend strongly to confirm the observation previously made as to the less frequent occurrence of tetanus of late years among the wounded of armies.

Tetanus in particular regiments during the Crimean war.— Out of the 21 cases which occurred among the wounded men of the British army in the Crimea during the war of 1854–56, 3 cases, or one-seventh of the whole number, occurred in the 19th Regiment, of which I was at the time in surgical charge, and a similar number in the 88th Regiment, which was encamped next to it. The fact is the more noticeable, as there was a fourth case of tetanus in the 19th Regiment, though the disease in this instance did not follow a gunshot wound. Thus nearly a third of the total number of cases of tetanus which occurred throughout the war in the Crimea happened in the two contiguous camps of the 19th and 88th Regiments.

The two regiments were encamped on the west side of the entrance to a long, deep, and narrow rocky ravine—the Karabelnaia—the 19th being the nearest to it, and receiving some of the surface moisture from the ground occupied by the 88th Regiment, on account of the general slope towards the valley. It seemed not improbable that damp exhalations from the ravine, carried along by the strong currents of wind which often blew from

it, together with variations of atmospheric temperature, were the agents which had the chief influence in producing the disease in the two regiments. All the cases that followed gunshot wounds in the 19th Regiment occurred in the month of September 1855, and the idiopathic case took place on the second day of the succeeding month. There was a great preponderance of rain during this period. The daily thermometric range was considerable, the air being hot under the influence of the sun in the daytime, but cold and chilly at night. High northerly winds also prevailed during the month of September, and these blew almost directly up the ravine towards the position on which the 19th and 88th regimental camps were placed. No cases occurred in the regiments which were encamped on the opposite side of the valley or head of the ravine. The men of the 19th Regiment were at the time in good health; no deaths took place in it, among officers or men, except from gunshot wounds. The camp was kept scrupulously clean, and sanitary rules strictly enforced. All the four cases of tetanus in the 19th Regiment terminated fatally. In one of the three gunshot wounds the tetanus supervened on a compound comminuted fracture of the right pubis, with a wound of the testicle, caused by grape-shot, on the 26th August 1855. In the second, which occurred on the 8th September 1855, a rifle bullet entered just above the left knee and disappeared. Seven days after the wound was inflicted, an abscess was opened near the tuberosity of the left ischium, and from this spot the bullet was extracted. Tetanic spasms appeared in the limb on the same day, and gradually spread to all the other parts of the body. The patient died within seventy-two hours after the tetanus first made its appearance. The bullet was found to have injured the sciatic nerve. It was reddened superficially, and its substance, under a magnifying-glass of low power, showed indications of inflammation. A piece of cloth was also found lying midway in the long sinus-like wound made by the bullet. In the third case, which occurred on the same date as the preceding one, a bullet entered the upper and inner aspect of the right shoulder, passed through the axillary region, and made its exit near the inferior angle of the scapula. The nerves had apparently escaped lesion. The patient progressed favourably for some days, when the tetanus appeared and quickly proved fatal. After death some detached pieces of woollen cloth were found lying entangled among the axillary plexus. In the fourth case, which happened to my own soldier-servant, trismus appeared on the 2nd October 1855. General tetanic symptoms were speedily developed, and the patient died on October the 5th, three days after the beginning of the attack. On trying to discover a local source of irritation, the man told me he had hurt the sole of his foot slightly by the point of a nail about a week before, but neither at the time on careful examina-

tion nor after death could I find any reliable indication of local injury. The disease might well have been idiopathic in origin.

All kinds and conditions of gunshot wounds liable to tetanus.—No one kind of gunshot wound, no stage, nor any particular condition of a wound, appears to be more free from liability to tetanus than another. It has been observed in the simplest and in the most complicated wounds—in wounds in an unhealthy, and in others in a healing condition. Dr. Brown mentions that out of six cases that fell under his own care in Lucknow, the wounds were granulating in three instances, and were in a sloughing condition in the remainder. A case hereafter mentioned shows that though a gunshot wound may be completely healed, tetanus may still occur. In the majority of the cases which occurred in the British army in the Crimea, direct injury to nerves preceded the symptoms of tetanus, and in some instances foreign substances were lodged, and acted as sources of irritation to them. Of the total 21 cases, ascertained injuries to nerves by missiles, or by division in amputation, occurred in 11 cases. In the only case which recovered, the wound was caused by pieces of an exploded shell which lodged in the gluteal region. One fragment, nearly a pound in weight, was removed soon after the wound was inflicted. Trismus set in seventeen days afterwards, when a further examination of the wound led to the discovery of another fragment of the shell. It was angular, and was resting against the sciatic nerve. When this fragment, which was found to weigh 18 oz., was removed, the sheath of the nerve was seen to be torn for nearly an inch in extent. The tetanic symptoms subsided under treatment by calomel and opium to salivation, and the patient gradually became convalescent. In this instance the disease never acquired the extent of general tetanus; but on the day after the removal of the second fragment, it had so far advanced that trismus was complete, while there was considerable rigidity of the muscles of the limb on the wounded side, and stiffness of those on the opposite one.

Lodged pieces of cloth sometimes an exciting cause.—In two of the cases which fell under my own notice in the Crimea, fragments of cloth were found in the wounds after death. In 1861 a French military surgeon, M. Maupin, published an account of two cases of tetanus after gunshot wounds, in both of which the tetanic symptoms seemed to be attributable to irritation from the lodgment of pieces of cloth.[34] In one, a quartermaster-sergeant was wounded by a bullet in the right thigh, about four inches below the groin. The projectile passed through the limb, leaving a bridge of five fingers' breadth between the two openings. All went on well till the ninth day, when pain was complained of in and around the wound. Four days afterwards trismus and cramps of the injured limb appeared. The spasms increased, passing to the left lower

extremity also; but they still continued more energetic and painful on the wounded side. The whole body finally participated in the spasms, and the patient died on the twelfth day after the onset of pain in the wound. After death fragments of the soldier's trousers and drawers were found lying in the wound. In the second instance, on tetanus supervening, the track of the bullet was laid open with the intention of destroying the sensibility of the surface by cauterisation. When, however, the track was exposed, a piece of cloth was found to be lying in it. This was removed, no cauterisation was practised, and the spasms gradually ceased.

Nerve lesions and tetanus.—Many cases of tetanus have been met with in which foreign bodies penetrating nerves, such as a fragment of shell, a piece of lead, a point of broken bone, and other like causes of local irritation, have been found after death, and hence have been regarded as the causes of the disease. But though these may have been the exciting causes in the particular instances named, such nerve lesions will not always suffice to explain its occurrence. Examples without number of similar injuries to nerves could be quoted without tetanus ensuing as a consequence. A small portion of a bullet has been found, after amputation of a limb, firmly imbedded in the radial nerve, and yet the original wound healed without any tetanus or other complication occurring. The amputation was performed, some time afterwards, for excessive pain in the course of the nerve, and was followed by instantaneous and permanent relief. On dissection, the radial nerve was found blended with and intimately attached to the cicatrix of the wound for the space of an inch. On examining the nerve, 'there was a small portion of the ball firmly imbedded in it, which had been driven off by grazing the bone.'[35] This was just a case in which the occurrence of tetanus might have been expected. Dr. Mitchell, who had special and very extensive opportunities of studying the effects of gunshot lesions of nerves in the war of the rebellion in the United States, has observed that 'the tendency towards irritation resulting in spasm seems to increase as the nerves divide and approach the skin.' He expresses his conviction that 'in the mass of tetanic histories the casual irritation has arisen in the extreme distribution of nerves, and where there has been no proof of previous injury to large trunks;' and as evidence in favour of this statement, he mentions that there was not a single case of tetanus among two hundred instances of wounds of great nerves which had passed under his observation during the war.[36] This testimony bears very strongly against the notion of gunshot wounds of nerves being an adequate cause of tetanus without being combined with other special conditions.

Effects of climate and atmospheric changes.—It is generally admitted that tetanus occurs in larger proportion among the

wounded after actions in tropical climates than in more temperate latitudes; and that exposure to chills caused by damp night-air, such as is often met with in succession to a high day temperature in hot countries, has an especial effect in producing it. Baron Larrey remarked among the wounded of the French army in Egypt that gunshot injuries of nerves and wounds of joints were often followed by tetanus when the weather passed from one extreme to another, especially in marshy situations such as those adjacent to the Nile; while if the temperature of the air remained equable, its appearance was rare. He made the same observation with regard to the occurrence of tetanus during the Austrian campaign of 1809. The wounded who were the most exposed to impressions of cold and damp during the frosty nights of spring, after having been subjected to a high temperature during the day, were nearly all attacked by tetanus. It only prevailed at that season. He also noticed that the disease was more intense in Egypt than in the more temperate climate of Austria.[37] In the United States' Preliminary Report on the Surgical Records of the War, it was remarked that 'the records abound with illustrations of the influence of sudden vicissitudes of temperature in producing this fatal affection (tetanus), and of the effect which unextracted balls and other foreign bodies, and matter confined under fasciæ, appear to exercise upon its development.'[38] Tetanus is stated by Dr. Reeb to have prevailed at one time at Strasburg during the siege in 1870, and he remarks that its appearance coincided in a remarkable manner with the depression of temperature and rains at the beginning of September. Médecin Principal Dr. D'Expers has also recorded, with regard to the occurrence of tetanus at Metz during the war, that the cold, which made itself felt especially at night, caused a sort of epidemic of tetanus, and carried off many of the wounded, both those who had been operated upon and others, with great rapidity.[39]

Dr. Hammond, who directed the medical department of the army in the United States at the first part of the war, has since written: 'It was not uncommon, during the recent war, for the number of cases of tetanus to be very much increased immediately after a sudden change of the weather from dry to wet and cold.'[40] All accounts indeed agree in attributing a special influence to alternations from high to low degrees of temperature in the production of this complication, especially when joined with a damp atmosphere. Want of proper food, deficient clothing, and moral and physical depression are sometimes cited as predisposing causes of tetanus among wounded men; but it is questionable whether an appreciable influence is exerted by such circumstances alone. Want and depressing conditions probably never existed in a more fatal degree, consistently with the maintenance of an army at all, than they did in the English and Russian armies in

the Crimea during part of the winter of 1854–55; yet tetanus was almost unknown at that period.

Effect of irritation of wounds by local disturbance.—Among other causes to which the occurrence of tetanus in armies has been attributed have been the jolting and disturbance of wounds caused by the conveyance of patients in vehicles from the front to the field and other hospitals in the rear; but that this cause has ever added materially to the number of instances of the disease seems very doubtful.

That disturbance and irritation of gunshot wounds by undue movements, when they are in an inflamed condition, will act as one of the exciting causes of tetanus, particularly in hot climates, is certainly a fact. My attention was first attracted to this circumstance by my former colleague, Surgeon-General Maclean, C.B. His observations in China had shown him that interference with inflamed wounds for the removal of lodged projectiles (and owing to the inferiority of the weapons employed by the Chinese, the bad quality of powder, and ill-shaped bullets, most of them, when they penetrated, did lodge) was frequently a source of tetanus. As the observation seemed to be of practical importance, I asked him to give me a note on the subject. The following is the memorandum with which he kindly furnished me:—

'The only cases of tetanus during the 1840–42 war in China following gunshot wounds resulted from the well-meant but injudicious efforts of inexperienced young medical officers to extract lodged missiles from the wounds of soldiers, after inflammatory action had set in, and before suppuration was established. I cannot recall the exact number of cases in which this untoward event occurred, but there were certainly not less than six, with, in every instance, a fatal result. The practice was put a stop to, and I did not hear of another case afterwards. The wounds in the examples mentioned were received before Canton, and the treatment, followed by the consequences mentioned, was carried out on the passage down the river in the course of the two following days.'

At the time these cases occurred, the solar rays were very powerful in the daytime; but the nights were cool, especially on the river. It is highly probable that these changes of temperature, combined with the chilly night-air and untimely interference before mentioned, largely helped to develop the malady.

Specific micro-organisms a reputed cause.—Certain kinds of garden soil have produced tetanic symptoms in some animals by inoculation, and these effects have been attributed to a specific bacillus, which has also been suspected to be the cause of tetanus in man. A connection is supposed to exist between this bacillus, to which the name of *bacillus tetani* has been given, and horse-manure by some pathologists. If infection of the system by this bacillus or its products be accepted as the specific cause of tetanus

after wounds in military practice, it becomes very difficult to explain how, in any instance, when once the infection has occurred and the disease is in full course, amputation of a wounded limb, or the extraction of a missile or other substance in contact with a wounded nerve, nerve section, or any local surgical proceeding, can ever lead to a cessation of the tetanic symptoms; and yet it is well known there have been, though rarely, undoubted instances in which such operations have been followed by relief and ultimate recovery. It is recorded in the Surgical History of the United States War (vol. iii. p. 821) that amputation was resorted to in 29 instances after tetanic symptoms appeared, and that a favourable result ensued in 10 of these cases, while it was noted in several instances that the symptoms ceased after the operation. The difficulties indeed appear insuperable when endeavours are made to reconcile the agency of this reputed cause of tetanus with all the clinical conditions under which the disease has followed gunshot injuries on different occasions in naval and military practice. The investigations regarding the bacillus tetani, however, can hardly be regarded as complete. Some eminent pathologists have stated it to be doubtful, from a pathological point of view, whether it can be regarded as the exciting agent of the disease.[41]

Causes of tetanus in armies reviewed.—A reconsideration of all the circumstances under which traumatic tetanus has occurred in military hospitals seems to point to the fact that several causes have generally acted in combination in favouring the production of the disease. In addition to local sources of irritation from circumstances connected with the wounds themselves, there has probably been a special predisposition on the part of the patients to the affection; while, further, certain extrinsic agencies have contributed to the onset of the disease, especially great alternations of temperature with strong currents of damp air. When tetanus has attacked wounded patients in a considerable proportion, the personal susceptibility of the subjects of the disease seems to have been sometimes aggravated, or even induced, by nosocomial influences, particularly by an unwholesome condition of the atmosphere in which the wounded men have been placed. It is a noticeable fact that whenever tetanus has been recorded as having existed in an epidemic form among bodies of troops, the presence of other diseases indicative of an insalubrious state of things has been mentioned also. At the various periods when tetanus was a common affection in the Peninsular hospitals, it appears from Sir J. M'Grigor's report that contagious typhus, hospital gangrene, dysentery, and other allied diseases were also prevailing in an aggravated degree. How far a specific micro-organism is the essential parent in producing the disease seems at least to require further proof.

Course followed by tetanus in gunshot wounds.—Tetanus sometimes occurs as a complication of a gunshot wound in quite an unexpected and sudden manner, speedily assuming its severest forms of manifestation; while, in other cases, both its invasion and progress are comparatively gradual and slow. The sudden and intense forms of tetanus more particularly belong to hot climates. They do not seem to have been met with in any large proportion among the cases which have occurred during modern wars in Europe. As observed by surgeons, in recent years, the attack of tetanus has been not unfrequently preceded by some general indications of constitutional disturbance, as loss of appetite, torpidity of the bowels, uneasiness, and mental depression. Some fresh pain or more stiffness about the wound has been noted in some cases. But when these premonitory symptoms have occurred, there has been nothing special about them to indicate the serious disease of which they were the forerunners. The first indications of the disorder that usually excite the suspicions of the surgeon as to their cause are either spasmodic contractions near the seat of injury, or, what has happened more frequently, stiffness about the jaw or neck, which the patient at the onset has probably attributed to cold or rheumatism. With this latter symptom there is generally some difficulty in mastication and swallowing. These symptoms become more and more marked, while those of diaphragmatic spasm, with great pain at the scrobiculus cordis, and difficult respiration, are next added. The tetanic spasms extend to the muscles of the body and the extremities, especially the lower extremities, varying in intensity in different parts according to circumstances. The rigidity becomes greater, so much so that the jaw becomes completely '*locked*,' and the spasms recur at more frequent intervals as the disease advances. The muscles of the arms are usually the last seized, unless the wound has been in one of the upper extremities, when the muscular contractions appear more early in them. The muscles which have become affected hardly ever, if ever, become loosened into a state of complete relaxation; but, while more or less rigid and contracted, they pass into sudden uncontrollable paroxysms of still more violent contraction. These aggravated spasms appear at more frequent intervals, and are generally attended by pain of a very severe character. Sleeplessness is a general concomitant of the disease. The bowels remain constipated, urine scanty, micturition sometimes painful. Death sometimes follows an attack of violent spasm, or results from exhaustion, or, it has been stated, more frequently occurs during an attack of suffocation from spasm of the muscles of respiration.

Period of its occurrence.—The time at which a gunshot wound may become complicated by tetanus is variable. It may follow a wound quickly, or many days may elapse before it appears. By some this interval has been spoken of as a period of incubation;

but the length of time which passes before the attack occurs may well depend upon accidental circumstances, as much as the attack itself. There is a prevailing belief that the more speedily tetanus occurs after a wound, the more certain is it to terminate fatally; while the more prolonged the period, the more chance is there of recovery. Mr. Poland, in illustration of this point, has mentioned that of 277 collected cases of tetanus, 130 occurred previous to the tenth day after the injury, and of these 101 died; 126 cases from the tenth to the twenty-second day, and of these 65 died; 21 cases above twenty-two days, and of these 8 died.[42] These observations overthrow the conclusion which Sir J. M'Grigor mentions the Peninsular surgeons had come to—that if tetanus does not occur for twenty-two days from the date of the wound the patient is safe. The following case, the particulars of which were given to me by Surgeon Applin of the Royal Artillery, shows that tetanus supervening on a wound may not manifest itself until some months after its occurrence, long after the wound has become healed. The subject of it was a younger brother of Dr. Applin. His gun exploded while he was out shooting, and the top of his left thumb was carried away. Amputation was performed, and on the wound becoming healed, he returned to his studies. Nearly four months afterwards trismus suddenly appeared, and he expired on the following day during a severe fit of opisthotonos. This case somewhat resembles one of a patient in Guy's Hospital related by Mr. Morgan. A sailor had a lacerated wound of the thumb; it had been transfixed by a piece of teak wood. The wound healed perfectly. About two months afterwards a painful neuralgic affection of the muscles of the thumb came on; tetanus followed, and he died. On dissection, two small splinters were found in the abductor muscle against a branch of the radial nerve.

Cause of the general immunity from tetanus in the Crimean war.—To what circumstances are we to attribute the comparative immunity from tetanus which the wounded of the Crimean armies, English, French, and Russians, enjoyed, notwithstanding the wretched state of the troops during considerable periods of the war? Certainly the contrast between the proportionate number of cases which were met with during the Crimean war, and the numbers which have been recorded in previous wars, is very remarkable. I am inclined to attribute the absence of tetanus from the field hospitals principally to the following circumstances: the free circulation of fresh air from the sea over the elevated and well-drained plateau on which the armies were encamped; the fact that the wounded were treated in separate tents or huts; and probably also to a generally simpler treatment of the wounds themselves than had been formerly in vogue. But the active circulation of pure, and at most seasons comparatively dry air, was probably the most efficient preventive

of the disease. Improved hygienic arrangements, wider separation of beds, allotment of more cubic space, with greater purity of surrounding air, have undoubtedly contributed to the diminution of tetanus in recent wars, as they have done also to the prevention of hospital gangrene and other allied diseases among the wounded of armies. The polluted conditions of the general hospitals during the early campaigns of the present century have been very strongly animadverted upon by distinguished surgeons. So the prevalence of tetanus in Lucknow in 1857 may be in a great measure explained by the circumstances of the troops—hemmed in as they were by the enemy, overworked, and subjected to all kinds of depressing influences, mental and bodily, in a tropical climate; while the hospitals were not only unavoidably placed amid extremely insanitary surroundings, but had become internally infected by the emanations of the many wounded who were successively and without intermission placed in them. The comparative rarity of tetanus among the wounded in modern naval engagements has, no doubt, also been due to the greater attention which has been given to hygienic arrangements, since the importance of due sanitation has been better understood by commanding officers. Dr. Dickson, Physician to the Fleet, read a paper before the Medico-Chirurgical Society upon cases of tetanus that he had observed among soldiers of the expeditionary forces against New Orleans in 1815, and, in doing so, referred to the diminished proportions of the disorder in the engagements of that period on the West India station as compared with the proportions in previous wars in the same climate. He was led to attribute this difference chiefly to improved hygienic circumstances. He concluded his remarks by the following summary: 'I trust I am therefore justified in inferring that to the improvements in the medical and surgical treatment of wounds; in cleanliness and ventilation, avoiding at the same time exposure to currents of cold air or sudden changes of temperature; in fine, to superior comforts, diet, and accommodation, and particularly to the greater attention paid to the state of the bowels, may be attributed the great infrequency of tetanus of late in the West Indies when compared with former wars.'[43] The superior comforts, diet, and treatment would have hardly had much influence in lessening the tetanus, without the improved ventilation and greater cleanliness mentioned by Dr. Dickson; for, destitute of good accommodation, good diet, and comforts, as the troops in the Crimea were in their first winter, there was no prevalence of tetanus then. The few cases of tetanus which did occur among the wounded took place at the time when the troops, and especially the wounded among them, had everything that could be desired in these respects.

Tetanus in its acute and chronic forms.—Larrey, in his first

memoir on tetanus, divided the disease into acute and chronic tetanus, and this division has been generally accepted since as a practically useful one. There does not appear to be, however, any essential difference in nature between the two forms of the disease. The acceleration and severity of the symptoms in the one case, and their relatively slow progression in the other, appear to be only indicative of a more or less powerful exciting cause, or of a more or less susceptible state on the part of the patient. But repeated observation has shown that when the intense symptoms occur which characterise the disease in its acute form, it is almost without exception fatal; while, when it presents a more chronic character, in a certain proportion of the cases, though only a small one, it is amenable to treatment, and recovery ensues. Hennen, whose opportunities of observing the disease were very extensive, owing to his having had charge of some of the most important surgical hospitals in the Peninsula between 1811 and 1814, and of the large Jesuits' Hospital at Brussels after the battle of Waterloo, wrote, 'I have never been fortunate enough to cure a case of acute tetanus; in some instances of the chronic species I have effected or witnessed relief.'[44] The records regarding tetanus during the prolonged United States war equally show that the recoveries mainly occurred in cases of a chronic description. In nineteen cases of recovery noted in the Surgical History of the war the disease lasted from nine to forty-nine days. The lesson taught by the experience of this war was, on the whole, that the later the disease showed itself after the injury, and the longer its duration, the better were the prospects of life being saved.

CHAPTER VII

ERYSIPELAS AFTER GUNSHOT WOUNDS

General remarks.—The occurrence of erysipelatous inflammation in a gunshot wound is a complication which formerly was a subject of much dread among surgeons of military hospitals; not only on account of its direct effects on the particular wounded men attacked by it, and its liability to spread to the wounds of other patients, but also on account of the difficulty of eradicating it from hospitals which circumstances did not permit to be emptied of patients and thoroughly disinfected.

Experience of it in war.—Erysipelas was one of the constant scourges of military hospitals during the early wars of the present century, but since those days it has gradually lessened in frequency, almost in proportion as the evils of overcrowding and the import-

ance of systematic hygiene and surgical purity have become better and more widely appreciated. Even in the time of the Crimean war its incidence in the field hospitals was a rare event, and later on, especially since the introduction of the antiseptic treatment of wounds, its occurrence has become quite exceptional, and its dissemination on occasions of its appearance still rarer.

A full account of the disease as it was experienced in the United States during the war of the rebellion is furnished in the Surgical History of that war. It really was at that time a relatively rare occurrence, although the accumulated number of instances of erysipelas shown in the history is very considerable. The number tabulated amounts to 1097. This number gives a proportion of only 0·4 per thousand of the gunshot wounds tabulated during the war. Of the aggregate named, 457 cases, or 41·7 per cent., occurred in wounds of the upper extremities; 429, or 39·1 per cent., in wounds of the lower extremities; 154, or 14 per cent., complicated wounds of the head, face, and neck; and 57, or 5·3 per cent., wounds of the trunk. When the cases of erysipelas are compared with all the wounds in each of the bodily divisions above named, it is shown to have occurred most frequently in wounds of the head, face, and neck, being in the ratio of 5·8 per thousand; next in wounds of the upper extremities, among which it appeared in 5·2 per thousand; then in wounds of the lower extremities, 4·7 per thousand; and least frequently in those of the trunk, where it complicated only 1·2 per thousand wounds. The number of cases in which it led to a fatal termination was 450, or 41·0 per cent. of the total number, but in some of these instances other complications joined in causing the fatal issue. In 60 cases the immediate cause of death was stated to be pyæmia; in 8 gangrene; in 5 tetanus; in 12 hæmorrhage; in 168 only the erysipelas was given as the sole cause of death. In 197 instances only the occurrence of erysipelas was recorded; the direct cause of death was not stated. Amputations were followed by erysipelas in 301, and excisions in 102 instances. The disease occasionally occurred under the most favourable hygienic conditions, but generally showed itself in crowded hospitals, with ill-ventilated rooms, in which it spread rapidly from one patient to another. The surgical history states that the wounded among the coloured troops seem to have been seldom affected by this complication, as only 11 were attacked by it; but in several of these instances it was attended by a fatal result.[45]

Wounds specially susceptible to erysipelas.—Gunshot wounds in all their stages are liable to be attacked by erysipelas, but they do not, as a rule, exhibit the same susceptibility to it while recent that they do at later periods. As happens in contused wounds from other causes, so, in those produced by gunshot, wounds of the head and face appear to be especially susceptible to its influence.

Patients suffering from wounds of the limbs with fracture of the shafts of bones, or with carious shot-canals in their extremities, when they have been long under treatment, and especially when the wounds are subjected to irritation such as sequestra are apt to occasion, seem also particularly prone to be attacked by erysipelas. Owing to the preponderance of cases of wounds of the extremities among those which remain a long time under treatment in military hospitals, it is more particularly in connection with these injuries that the occurrence of erysipelas has been noticed.

Causes of erysipelas.—Erysipelas in some sporadic instances has appeared to have arisen spontaneously, or at least to have been generated by a congress of conditions favourable to its birth and development; but there is every reason to believe that it is generally imported from without, and is communicated by direct contagion. In some of the cases which appear to owe their origin to specific communication, there may be a predisposing condition in the protracted hospitalisation and depressed state of constitution of the patient, or in the condition of the wound, or favouring circumstances in the locality in which the patient is placed; but other instances occur in which a wound is attacked by erysipelas where no such predisposition can be supposed to exist, the subject of the invasion being in a good state of general health, the wound granulating healthily, the dressings employed having been of the least irritating character, and where nothing unsanitary can be detected in the surroundings of the patient. Under such circumstances the only explanation of its occurrence seems to be the direct contact of a specific virus. Communication of the disease by contact has been so frequently observed in hospitals that no doubt regarding its contagious nature can be reasonably entertained. The presence of a specific microbe in the lymphatics and areolar tissue of parts affected with erysipelas has been demonstrated by bacteriologists, and the name *streptococcus erysipelatis* assigned to it; but the conditions on which the invasion of this microscopic organism depends are manifestly involved in great obscurity in particular cases, although its adherence to dried pus cells, and in this way its dispersion in the air, is believed to be the source of contagion in occasional instances of the disease.

Influence of depressed vital energy.—Depressed vital force has been stated to favour the occurrence of erysipelas in patients suffering from gunshot wounds; but that a low condition necessarily exerts an influence on its production was sufficiently disproved during the Crimean war. Never, perhaps, have troops been employed on service in whom vital energy was more reduced than it was in that portion of the Crimean army whose fate it was, after passing some months in the pestiferous valleys of Bulgaria, to be

stationed on the heights before Sebastopol during the winter of 1854–55. After being subjected to a long-continued visitation of cholera and choleric diarrhœa, officers and men had to undergo the further depressing influence of exposure to severe cold, continued damp, deficient shelter and clothing, a spare unvaried diet of innutritious and imperfectly cooked food, with harassing duties, until at last every survivor remaining on the plateau exhibited the most marked features of cachectic debility; yet erysipelas was not one of the diseases which attacked the patients who were under treatment for gunshot wounds. I did not myself see a single case of erysipelas at that time, and the hospital returns show that it was not one of the complications of wounds during that fatal period. Certain ingredients in the production of the disease were wanting: it was not introduced from without, nor was there the impure atmosphere to generate it within. During that trying winter the troops were under canvas in very permeable tents, and the free movement of the sea air over the bare peninsular plateau sufficiently prevented either atmospheric stagnation or impurity in the camps. When subsequently the tent hospitals were replaced by hut hospitals, the majority of those who had passed through the period of depression had succumbed to other diseases or had been sent away as invalids. Had erysipelas been introduced among the wounded at the time when the anæmic and scorbutic condition was universally prevalent, it is not unlikely it would have spread with rapidity among them, and have assumed a virulent and fatal character.

On the other hand, a generally healthy state of constitution and good hygienic arrangements will not always serve as a sufficient protection against the ingraftment of erysipelas, if it be introduced among men suffering from wounds. Erysipelas has been imported by newly arrived patients on several occasions into the invalid hospital at Netley, but the measures taken have always succeeded in preventing it from spreading. On the last occasion of its appearance, however, the erysipelas arose in the hospital itself. It happened in the year 1882, when the surgical wards were filled with invalids suffering from wounds, over 200 having been admitted from Egypt subsequently to the battle of Tel-el-Kebir. Nearly all were gunshot wounds, and in a state of suppuration. One, and only one case of erysipelas occurred among the whole number. This attack, which proved extremely severe, nearly costing the patient's life, affords some special points of interest as regards the circumstances of its occurrence. The patient concerned, a soldier of the Life Guards, while mounted, had been wounded in the foot at Kassassin by a large fragment of a shell which had exploded on the ground close to him. A considerable part of the left os calcis was carried away, and the remaining portion, as well as part of the astragalus, were

carious on the man's arrival at Netley. He was placed in a large and airy ward, but every bed in it was occupied by men with gunshot wounds. One morning, after he had been in the hospital about three weeks, it was considered desirable to make an examination of the wound, and a probe was handed from a tray containing carbolised solution for the purpose of the exploration. Just as the instrument was about to be used, there came a call of great urgency from another ward, and, in the hurry of leaving to attend to it, the probe was inadvertently thrown down on the patient's bed. At the same time, the examination was postponed to the visit of the following morning. It was then made, the simple proceeding lasting only two or three minutes. On the evening of that day the patient complained of stiffness and uneasiness about the foot—he felt generally unwell—and his temperature had risen. In the course of the following day there appeared about the wound an inflammatory blush, which was suspected to be erysipelatous. The patient was at once removed to an empty ward and isolated. The measures adopted did not stop the erysipelas; it extended upwards to the leg and thigh, and invaded the abdomen up to the level of the umbilicus. Its farther spread was then arrested. The extension of the erysipelas was accompanied by constitutional symptoms of the gravest character; but eventually, after almost all hope of safety had been abandoned, the patient recovered. No other wounded patient, either in the ward from which the case of erysipelas was removed, or elsewhere in the hospital, showed any sign of the disorder. A strict inquiry was made into all the circumstances of this case, and it was then discovered that the probe, with which the examination into the state of the denuded bone had been begun to be made, had been permitted to remain on or near the patient's bed during the twenty-four hours which had lapsed from the time of the interruption. It was also found that it had neither been cleaned nor placed in the disinfecting fluid, as was taken for granted by the surgeon had been done, before it was handed to him for use on the second occasion. Had it in the meantime become coated with septic material sufficient to poison the wound, and so originate the dangerous attack of erysipelas that followed its employment? The circumstances rendered it probable that in this instance the disease, the only example of it among so many wounds of a similar nature, had been produced in the way mentioned.

Site of wound attacked.—The degree of gravity of an attack of erysipelas does not merely depend on the power of constitution and state of health of the patient. The situation of the wound which has become the subject of the erysipelas also exerts an influence in this respect. Thus wounds about the neck attacked by erysipelas are rendered dangerous by the swelling of adjoining parts and the risk of the larynx becoming implicated in the

inflammatory action, inducing œdema of the glottis; wounds about the head, from the risk of meningeal and cerebral complications; while in wounds of the extremities, one of its most common situations, in its simple form it is, as a general rule, far less hazardous. When erysipelas invades a wound of one of the extremities, especially of the lower extremity, and is complicated by diffuse inflammation, much infiltration and swelling of the subcutaneous areolar tissue, the symptoms which accompany it, are then apt to assume a very aggravated character, and are often followed by the gravest results in patients who have been a long time under hospital treatment.

Early symptoms.—The occurrence of erysipelas rarely takes place in a patient without some symptoms of constitutional or visceral disturbance being exhibited previously. There is usually a failure of appetite, constipation, or some other indications of want of regularity in the digestive functions, for one or two days before the attack. The patient, after some disturbed sleep, awakes with headache, or he complains of not feeling so well as he has been feeling, without being able to define any particular ailment; states that he has been restless and fidgety, and that he has felt drowsy, or wearied, or chilly. Perhaps he has an attack of rigors, which, if he is a subject of malarial poisoning, he believes to be the onset of an attack of ague. The temperature rises, the pulse increases in frequency, and the other usual indications of a state of pyrexial disturbance are present. As these symptoms are noticed, the wound loses its healthy character, and the disease soon makes itself manifest. The premonitory symptoms which have been just mentioned may, however, be so slight as not to be observed, and the local evidence at the wound itself may give the first indications that erysipelas has set in.

Course taken by simple erysipelas in gunshot wounds.—There is no peculiarity in the manner in which erysipelas attacks a gunshot wound, nor in the phenomena which attend it as compared with other wounds. The affected skin is of a bright pink or red colour, tight, shining, and hot to the touch; as the erysipelas spreads, the parts convey a feeling of burning and tingling or smarting to the patient; the edges of the wound become swollen and probably somewhat everted; granulations appear pale and œdematous; the discharges from the wound become thin, serous, scanty, or are almost entirely suppressed; there is a marked contrast between the colour of the inflamed and adjoining healthy skin, but no defined rigid boundary can be felt by the fingers between them, as in ordinary phlegmonous inflammation; the erysipelatous redness exhibits a tendency to extend itself; on pressure by the finger the redness fades away, but it quickly returns when the finger is removed. The inflammation, if it be of a mild character, may be entirely confined to the skin,

and it may sometimes be difficult to distinguish it from ordinary erythema; or it may secondarily involve the subcuticular areolar tissue, and be accompanied with increased swelling in consequence, and this swelling may extend to a considerable distance from the seat of injury. In the former case the erysipelatous inflammation may gradually disappear after a few days, its disappearance being followed simply by desquamation of cuticle; in the latter case the inflammation will probably be of much longer duration, and may be followed by the formation of small abscesses at different points beneath the inflamed surface.

Phlegmonous erysipelas.—But the erysipelas may assume a far more formidable form than either of these above mentioned. The deeper structures may become so involved in the inflammatory action, and the inflammation may be so unrestricted and severe in its character, that not only diffuse suppuration, but mortification of the structures involved in it may result. This is the form which is usually designated 'phlegmonous erysipelas,' while the milder varieties are spoken of as 'simple erysipelas.' Parts which conveyed to the fingers on pressure a hard, firm character, become soft and boggy. If the skin ulcerates or sloughs, or is opened, it is observed to be undermined, while fetid pus mixed with dead connective tissue is found diffused beneath it. In wounded men who have become much debilitated in the course of a trying campaign, this form of erysipelas is liable to extend so far from the seat of injury where it commenced, and such great destruction of tissues to take place, that the patient's powers usually become taxed beyond endurance, and a fatal termination ensues.

CHAPTER VIII

TRAUMATIC DELIRIUM AFTER GUNSHOT WOUNDS

General remarks.—The delirious excitement which is sometimes met with in subjects of gunshot wounds is another complication which, when it occurs, causes much trouble and anxiety to military surgeons. It differs in certain particulars from delirium tremens, although in occasional instances the excessive irritability of the patient's nervous system may be partly due to the habitual use of alcoholic drinks prior to the infliction of the gunshot injury which has directly led to the excitement; or, if the use of intoxicating liquors be not habitual, then to excessive indulgence in them just before or at the time of the injury. Immoderate use of strong tobacco has been supposed to have had the effect of producing in some instances nervous and delirious

excitement after exhausting wounds. In other cases, however, no such direct influences as these exist, and the occurrence of the complication is manifestly due to an exhausted and irritable state of the nervous system, sometimes induced by physical, sometimes by mental causes, but always associated with depressed vital power. The exact nature of the patient's state cannot be defined, but it is one which renders his nervous system specially susceptible to disturbance, and liable to exhibit the effects of this disturbance under the form of excitement and delirium when a part of his frame has been subjected to sudden violent injury.

Temporary excitement after gunshot wounds.—Whenever a gunshot injury is attended with general shock, more or less disturbance of the cerebral functions is one of the phenomena which accompanies it. Consciousness may be entirely lost for a time, or, in addition to a certain amount of interference with general power of motion and sensation, there is mental confusion and bewilderment, varying in degree in different individuals. In occasional instances a person, after having been shot, becomes the subject of insane excitement, talks incoherently, loses touch with the scene and circumstances around him, and shows by his manner and expressions that he has ceased to be able to control his thoughts and actions. In soldier's language, 'the shot has turned his brain.' In some instances this excitement simply shows itself in unrestrained exaggeration of language and conduct, in others in uncontrollable rage against the enemy, in others in convulsive weeping of a hysterical character; such manifestations being often quite foreign to the natural dispositions or ordinary habits of the patients concerned. The condition is probably traceable to the conflicting emotions aroused by the consciousness of a sudden injury in persons who are already in an overwrought state of mind—in men who have been stirred up into a whirl of passionate excitement by the clamour and thrilling incidents of the struggle in which they have been engaged. It varies in duration, as it does in degree, in different individuals; but it rarely lasts long, and not unfrequently ends in a state of languor and inertness as noticeable as the previous state of exaltation.

Nature and symptoms of true traumatic delirium.—Such fugitive mental aberration is not, however, what is understood by the complication under notice. To warrant the name of 'traumatic delirium' something more is needed than that condition of passing excitement or disturbance of the intellectual faculties which is sometimes produced by the direct effects of physical commotion, or by excessive mental agitation, on the receipt of a gunshot injury. There is often no sign of it in the early condition of the patient, which may be one simply of shock with depression unaccompanied by any observable mental disturbance. In a day or two after the injury, the mind, which up to that time had been calm and com-

posed, begins to wander; a condition of nervous excitement is shown by the intense expression and alertness of the patient's eyes; the patient becomes the subject of delusions, generally of an agitating and alarming character; he does not sleep, becomes more and more restless, and has an anxious expression of face; the wound does not attract his attention; if it be accompanied with pain, it is not complained of, and appears not to be felt, for, if not restrained, the patient will sometimes aggravate the injury already existing to an extent which must in itself be productive of increased pain; all circumstances which act on the nerves of sight and hearing—such as the movements about him of attendants, strong light, noises of all kinds, especially abrupt and loud noises—add to the agitation of the patient; the surface of his body is moist, the perspiration perhaps being even profuse; the pulse is irregular, but readily yielding to pressure by the finger—not full and bounding, as in inflammatory fever.

The mental condition of the patient is often as curious as it is painful to witness. He appears to be taking an active part in some exciting and distressing dream, although he is in a state of full wakefulness. Everything around him adapts itself to the train of thought which forms the subject of his delusions, just as occurs in the dreams of sleepers. Even such realities as his wound, and the pain caused by it, cease to be recognised, or are made to chime in with the general subject of his thoughts. In this early part of the attack the patient may be temporarily recalled to a state of normal consciousness by the surgeon, so far as complying with simple directions that may be given to him; but as the nervous excitement becomes intensified in the progress of the case, even this power of arousing the patient to a sense of realities about him ceases. The patient becomes completely the victim of his delusions, so that he cannot be diverted from them even for a moment, or be made to appreciate intelligently any words that may be addressed to him.

This condition of nervous excitement without repose, if long continued, eventually exhausts the patient, and induces a fatal termination of the case, in many instances by cerebral effusion; if, on the other hand, remedies produce the desired effects, the cerebral disturbance becomes lessened by degrees, sleep is obtained, a condition of nervous and mental tranquillity is gradually restored, and the patient recovers.

Traumatic delirium and delirium tremens.—The difference between traumatic delirium and delirium tremens induced by excessive alcoholic drinking is chiefly marked by the absence of that trembling condition of the limbs which attends, and has given the name to the latter disease. Agitated as the arms of the patient suffering from traumatic delirium may be, and constant as their movements may be, there is not to an observer any apparent want

of general muscular firmness in them. The effort which is made to reach or remove some imaginary object is usually made in a hurried and jerking manner, but in other respects is as it would be if the object aimed at were real; it is not marked by those unconnected tremulous motions which so constantly accompany the general movements of persons in whom those morbid changes in the brain and nerve structure have occurred which are brought on by the continued abuse of alcoholic stimulants. At the same time there is undoubtedly close analogy between the two diseases, though the causes which induce them may be different. The same state of constitutional depression, with excessive nervous irritability and excitement, exists in both diseases. The liability to dangerous nervous excitement and delirium when surgical operations have to be performed on persons habituated to the use of intoxicating drinks, or when persons who are not habitual drunkards meet with grave injuries while in a state of drunkenness, and the increased mortality in such cases, are familiar to all surgeons. The traumatic delirium which then ensues has all the characteristic features of delirium tremens.

Special causes with troops on active service.—Traumatic delirium in field practice is usually met with in soldiers who have become lowered in constitutional tone by disproportionate fatigue, most especially such as arises from excessive night duties, with the interrupted and limited amount of sleep, and the forced strain on the attention which they entail, but also by that which results from long and harassing marches, irregular meals, exposure to inclement weather, and other disturbing and trying circumstances incidental to field service. Under these conditions, but more particularly those of broken rest and watching of a responsible and often anxious character, an abnormal irritability of the nervous system is engendered. The irritable condition thus induced will be aggravated by loss of blood, sudden shock, pain, and startling emotions incidental to the reception of a gunshot wound. If the wounded man has been recently indulging in the use of spirituous drinks, the depression will be all the lower, and the less will he be able to bear up against the additional strain which the gunshot injury entails on his nervous system. One of the most distressing and rapidly fatal cases of traumatic delirium I ever saw occurred in a tall powerful officer, Captain K., who received a very severe wound at a time when deprivation of sleep and a certain amount of over-stimulation by alcoholic liquor, but not approaching intoxication, had combined to place him in a state of nervous exhaustion. He had served in the field from the time the army landed in the Crimea. During the night of the 4th November 1854, he was kept constantly on the alert by the enemy while on piquet duty, and had just returned to camp, very tired and exhausted, when he was again ordered to the front.

The battle of Inkerman had commenced on the right front of the position. Captain K. had filled his pocket-flask with some spirit the evening before when going on duty, and had drunk its contents in the course of the night. He had only time to take a cup of coffee which his servant had poured out for him, and into which he poured a little rum to arouse his flagged energy, before he again moved off with his party toward the front. He had scarcely reached his place of destination when a heavy round shot struck him on the left knee, smashing the joint, and leaving the leg hanging only by skin and shreds of contused tissues. I had to amputate the limb at the lower third of the thigh. Scarcely any blood was lost at the operation, and very little bleeding had occurred at the time the wound was inflicted. He rallied sufficiently from the shock of the injury and succeeding operation, was very easy and comfortable throughout the day, and no symptom indicative of approaching danger showed itself. He, however, got no sleep that day, and only very disturbed sleep during the night which followed it. The next day traumatic delirium set in, and at last assumed a character of most violent excitement with distressing hallucinations, leading to the necessity not only of close watching, but also of restraint by two attendants to prevent him from injuring himself. The delirium continued during the succeeding night, and eventually, on the morning of the third day (the second after that on which the wound was received), extreme exhaustion and coma terminated the sufferings of the patient.

At the time when it was necessary to remove wounded men, or men upon whom operations, such as amputations, had been performed shortly before, from the front to the port of Balaclava for passage to Scutari, the additional exhaustion resulting from the disturbance and fatigue of the journey sometimes caused the men on their arrival at Balaclava to be in a state of partial delirium. Rest, nourishment, and appropriate remedies, in most of these instances, restored the patients to comparative calmness; but at one period of the war, so great was the prevailing prostration, and so seriously exhausting the journey to Balaclava, from its having to be performed by the patients on led cavalry horses (the only means by which it could be accomplished during part of the first winter), that in many instances men died on the way from utter loss of all power and syncope; while others became the subjects of delirium, and, when such delirious excitement occurred, it was only the prelude to a quickly fatal termination.

Effect of discharges of ordnance, and of panic, among wounded soldiers.—Another source of traumatic delirium is occasionally met with in time of war, when men who are disabled by the effects of wounds are subjected to intense mental agitation from an overwhelming sense of danger which they are conscious

they themselves are unable to avert. The agitating effects of the startling loud reports, the vibrations, and the sudden violent concussions produced by discharges of artillery, also predispose to the occurrence of the disease by the repeated shocks to the nervous system, and by keeping the senses of the wounded patients constantly on the alert, and so preventing regular sleep. Even persons in good health are frequently bewildered and upset by the commotion resulting from repeated discharges of ordnance; and it can readily be imagined that to men reduced in nervous tone by grave injuries, by loss of blood, and previous constitutional degradation from the circumstances of war, the agitation caused by sources of disturbance such as those above mentioned must often be so intense as to be likely to overthrow intellectual equilibrium. When a big service gun is about to be fired, the men who are concerned with it prepare themselves bodily and mentally for the circumstances attending the discharge; but when the gun is unseen and its discharge unexpected, an effect of the nature of shock is produced on the nervous system. Even such an experienced soldier as the Duke of Wellington was much startled, and, as previously stated, had the tympana of both ears ruptured by the sudden and unexpected discharge of a howitzer. A succession of such discharges from unseen guns at uncertain intervals cannot but have a seriously disturbing effect on weak and nervous patients, however accustomed they may have been to them when strong and at duty. These causes of traumatic delirium appear to have exerted a marked influence in some of the places besieged by the Germans during the Franco-German war of 1870–71. The remarks of two surgeons, Dr. Poncet and Dr. Reeb, on the prevalence of traumatic delirium in the military hospital during the siege of Strasburg are quoted by Dr. Chenu in his Surgical History of the war.[46] Dr. Poncet shows very forcibly the influence of mental alarm in the production of this complication. 'Nervous delirium has played such an important part,' he writes, 'in all the gunshot wounds, that one might well have believed at certain times that a veritable epidemic of it was prevailing. From the 25th to the 30th September nearly the whole of the wounded under our care, about 150, presented these nervous symptoms; one would have said the wards were filled with madmen. During the night of the 19th of September, the arsenal, which was only separated from our wards by the narrow Vauban canal, was destroyed by the fire of the enemy. At midnight a rain of sparks and flakes of fire covered the hospital; the brightness of the conflagration illumined the beds of the patients more vividly than at noonday; a favourable wind, and we had been enveloped in the flames. Numerous shells burst over the arsenal, keeping up the fire, killing and wounding those who carried assistance, and even penetrating to the centre of the hospital, and reaching some of the sick, who were incapable of

moving. A panic seized the wounded in spite of all assurances that assistance was organised and certain in case of need. Our amputated patients got up from their beds, men with fractured limbs disturbed the apparatus which had been applied to them—delirium became general. Some victims of hallucinations threatened the enemy; others, on the contrary, seemingly calm, followed with an unquiet and terrified look the progress of the fire or the path of the shells. The day following, when all immediate danger was removed, delirium broke out among those who had been the most calm during the previous night, and these cerebral disturbances were followed by general gangrene of stumps and ragged flaps of wounds, the initial rigors of pyæmia, and sudden deaths. It was on the 28th of September and following days that we had the greatest mortality.' Dr. Reeb particularly dwells on the pernicious results of the deteriorated atmosphere in which the patients were placed through agglomeration in one and the same building, and he evidently regarded the bad influence exerted by this cause as an important element in the development of nervous delirium among the patients. He remarks on the different results which he had witnessed in Algeria, where wounds and amputations healed readily, in spite of unfavourable conditions of transport, accommodation, and nourishment, owing to the purity of the atmosphere which surrounded the patients. Dr. Reeb points out that it was at the period when infectious maladies due to the local unhygienic conditions were most rife at the Strasburg military hospital that cases of acute delirium declared themselves in the greatest number among the wounded. At the same time he fully admitted that the continual cannonade, the prolonged wakefulness, the alarms from shells falling on the building, and from the threatening aspects of fires in the neighbourhood, contributed directly to its development.

It may be here remarked that it is always most difficult, under ordinary circumstances indeed impracticable, to comply with hygienic requirements in the treatment of wounded men in fortified towns and strongholds when they are in a state of siege, though the evils arising from hygienic difficulties may be lessened to a certain extent by an intelligent appreciation of them. The most urgent and most obvious necessity is to place the wounded where they will be least exposed to additional dangers from the projectiles of the besiegers. Hence the use of buildings as thickly covered and as strongly enclosed as possible, even cellars, for hospital purposes; and hence, also, in any place thought specially secure, an overcrowding fraught with the most deleterious consequences as regards the development of the various complications of wounds which have just been under notice. The difficulties military surgeons have to contend against in their efforts to ward off these complications are almost insuperable under such conditions.

Under all the circumstances which have been mentioned, the co-existence of depressed vital power in the wounded patient on the one hand, with relatively excessive nervous excitement on the other, may be observed constantly to concur in the production of the complication of traumatic delirium just discussed.

CHAPTER IX

PLAGUE OF FLIES IN CAMP AND TROPICAL HOSPITALS

General remarks.—In camp hospitals in warm weather, and in all hospitals in hot climates, wherever wounded men are congregated, flies collect and increase with wonderful rapidity. The greatest diligence is necessary to counteract the constant efforts of these insects to deposit their ova in gunshot wounds or their coverings, and to prevent the generation of larvæ in them, especially when sloughs are in process of separation. The fact of there being a difficulty of the kind must be hardly comprehensible to a surgeon who has only been accustomed to the circumstances of civil hospitals in fixed buildings, and in temperate climates, with all the necessary appliances and attendance at hand for systematically ensuring perfect order and cleanliness. Moreover, in a northern climate there are relatively few flies, and the introduction of the antiseptic treatment of wounds has been a sufficiently adequate protection against the invasions of the insects, even when temporary circumstances, such as a prolonged period of high temperature, may be favourable for their development. In former days larvæ appear to have been common enough as a complication of wounds, even in England, if we may judge from the records of them in old surgical works. They were so common, indeed, that *Ulcera verminosa* was a term in ordinary use. The surface of a wound appears to offer a very attractive situation for the deposit of their ova by flies: the odour probably attracts them to it, while the warmth and moisture seem to favour a very rapid development of the ova when once they are placed on it.

Plague of flies in the Crimean hospitals.—In camps flies seem to find the tents convenient places of shelter, especially double tents, such as hospital marquees; for they settle in large numbers on the inner lining of the roof. In the Crimea, for a certain season, the flies abounded in such numbers as to constitute a terrible plague. It seemed impossible to keep them in check. Though the wooden huts and tents were on a bare elevated plateau, surrounded on two sides by open sea, so that it might well have been supposed the wind would have swept them alto-

gether away, yet the flies were everywhere in myriads during the hot weather, and no plan seemed to succeed in reducing their numbers. They literally swarmed about the beds. If they were driven from one patient, they simply settled on another. All that could be done was to try and protect the wounds and sores from inroads of the flies; but although constant care and watchfulness were exerted by both surgeons and attendants for the purpose, their efforts were attended with only partial success. One advantage of marquees over wooden huts at this season was that the evil could be mitigated to a certain extent in them when a breeze was blowing, for the walls of the marquees could be raised, and thus a current of air be obtained over and around the beds on which the wounded patients were lying. But even in these at night, or during the early morning, while the tents were closed up, the flies would descend, and either from the dressings getting partly removed through the restlessness of patients, or in some other way, they would contrive to find access to the wounds. The 'plague of flies' is adverted to in the official report of the Crimean war, and the difficulty of devising means for ridding the wounded from it is thus described: 'The most scrupulous attention to the immediate removal of all dressings and bloody cloths, whether dry or recently stained, the most rigid enforcement of cleanliness, and the burial of all offal or refuse in the neighbourhood, failed, however, to do more than check the evil, and many and various plans were resorted to, first to prevent the deposit of the eggs, and, secondly, for the destruction of the larvæ, if they had gained access.'[47] The repulsive occurrence of larvæ in wounds was also occasionally a source of trouble during the United States war. The Surgical History states: 'The presence of maggots in wounds, in the field and camp hospitals, was frequently an annoying complication. After protracted battles, such as the fighting in the Peninsula in June and July 1862, and after the Wilderness and Spottsylvania in 1864, when the means of transportation were not sufficient to move the wounded rapidly to permanent hospitals, and when the number of attendants was entirely inadequate to the demand, maggots were found in abundance in and beneath the dressings and in the wounds. In well-established general hospitals the presence of maggots was rarely noted.'[48]

Irritation of wounded men caused by flies.—The mischief to wounded men when flies abound in such numbers as they usually do in camp hospitals in warm weather is not confined to the risk of their ova being deposited in the wounds, repulsive as this is both to the patients and their attendants. They produce pernicious effects in other ways. By settling on the faces or on other exposed parts of patients as they lie in their beds, they become constant sources of irritation, deprive the patients of their

proper amount of rest and sleep, and thus often seriously impede the progress of their cure.

During the Mutiny campaign in India in 1857 and 1858, as might have been anticipated under the circumstances of a tropical climate where insect life is so rife, the flies were everywhere a source of great misery to the British troops. Dr. Brougham, in his account of the siege of Delhi in 1858, remarks of the flies: 'This awful plague was beyond credence. I have seen them breed in the mouth, nose, and even in the urethra and anus of the wounded. How they penetrated even into the urethra is a mystery, but there could be no doubt of the fact, for in one instance the sufferer was unable to pass water until six maggots were extracted from the passage.' [49] This occurrence sufficiently shows the rapidity with which the larvæ must have been developed.

Species of flies which infest wounds.—In the Crimea and in India the fly commonly observed was apparently the same in species as the common house-fly met with in England. There is another kind of musca in India to which wounds may be subjected, the larvæ of which do not appear to be so easily destroyed as those of the ordinary domestic fly. An interesting report of a case in which death resulted in India from the *sarcophaga ruficornis* has been described by Staff-Surgeon Stewart in the 12th volume of the 'Army Medical Reports.' But the larvæ ordinarily met with in wounds in India and in Egypt, as well as in temperate climates, are those of the ordinary *musca domestica*. Baron Larrey, in his account of the Egyptian campaign under General Bonaparte, refers to the frequency of the larvæ of the common blue fly in the suppurating sores of the wounded. He describes the maggots as being formed in a few hours, and mentions that they increased in size so quickly that in the course of twenty-four hours they equalled the quill of a fowl in diameter. He remarks that the incubation of the eggs deposited by these flies in the wounds and dressings was not only favoured by the hot and moist atmosphere, but also by the quality of the material used for the dressings, which was cotton instead of linen, the latter not being procurable at that time in the country; while the continued speedy reproduction of them after the destruction of those in the sores was attributable to deficiency of the necessary means for keeping off the approach of the flies and so preventing the deposition of fresh ova. Notwithstanding the irritation and itching caused by the presence of the larvæ in the wounds, and the increased labour from the necessity of changing the dressings three and four times a day, Larrey was ingenious enough to discover an advantage from their presence. They accelerated the cicatrisation of the wounds, he writes, by abridging the work of nature, and provoking the detachment of the sloughs of the cellular tissue, which they in part devoured.[50]

SECTION VII

ULTERIOR CONSEQUENCES AND DISABLING EFFECTS OF GUNSHOT INJURIES

General remarks.—Soldiers who have been subjected to wounds are sometimes described as having recovered from their injuries when their wounds have become cicatrised; no reference being made in the remark to the consequences which have remained after the healing has been accomplished. It happens not unfrequently that men whose wounds have become healed, and who assert that they feel themselves quite restored to health and fit for work, are discharged to duty, when, after being subjected to practical trial, they are found quite unfit for ordinary military service. It is an important matter that the true conditions of such men should be recognised before they are sent to rejoin their regiments or corps, especially when the troops are stationed abroad; for their return to the ranks under the circumstances named entails the useless cost of their journeys to and fro, with expenses of maintenance, while their inefficiency causes extra duties to be thrown on other men who are present and efficient. Gunshot wounds very frequently leave behind them ill consequences, often of a grave character, after the lesions directly produced by the projectiles, or the surgical operations which the lesions have led to, have become entirely healed. Wounded soldiers are incapacitated for military service by the effects of their wounds in a considerable proportion after every war, although the wounds themselves have become sound. Such ineffective soldiers are technically described in military returns as 'invalids,' notwithstanding that their wounds may be quite healed and their general health perfect, and each invalid receives a pension varying in amount and duration according to the nature and degree of his disability. They thus become a source of great expense to the state in whose service they have become disabled. The proportions in which soldiers have been invalided after some particular campaigns will be noticed in the section on Statistics.

Some of the results of gunshot injuries are complete and permanent in character as soon as cicatrisation has taken place, as when a gunshot injury has necessitated amputation of a limb;

others, on the other hand, remain incomplete for long periods after the healing process of the wound has been accomplished. Alterations occur in some instances, as years go on, of such a nature as to diminish the disabling effects of the sequels of wounds; in other instances these sequels lead to the development of morbid conditions which become additional sources of infirmity and suffering, or even induce fatal consequences at remote periods after the dates of the original injuries.

One of the most fertile sources of prolonged inconvenience, pain, and secondary disease after gunshot wounds has hitherto been the presence of foreign bodies which became lodged at the time the wounds were inflicted, and, either from oversight, from the depth or particular situations to which they penetrated, or from some special difficulties in the way of their discovery or dislodgment, have remained unextracted; and although, from the qualities of the present small-bore bullets, when they inflict wounds they are very unlikely to remain lodged, the lodgment of other forms of projectiles, especially of shell fragments, judging from the published reports of experimental trials of modern shells, will probably be met with even more frequently than has hitherto happened in war.

When this complication has not occurred, the disabling consequences of gunshot wounds vary with the anatomical structures involved in the original lesions, and the complications which attended them before the healing process was completed. These consequences may be studied according as the lesions have occurred in particular tissues—the skin, connective tissue, muscular and tendinous structures, or bone. Again, they may be considered with reference to the particular regions of the body in which the injuries have happened, in accordance with the classification elsewhere described. Many points connected with the remote consequences of gunshot wounds in these special regions can only be discussed at the time that the circumstances and treatment of the particular injuries themselves are taken into consideration; but their general features may be described in this place with advantage. The remote effects of unextracted foreign bodies will be first noticed.

CHAPTER I

CONSEQUENCES OF LODGMENT OF FOREIGN BODIES

General effects very variable.—It has been previously shown, so far as the missiles discharged from portable fire-arms are concerned, that concurrently with the changes which have successively taken place in their forms, dimensions, velocities, and some

of their other qualities, a notable decrease has occurred in the proportions in which they have been liable to become lodged. It is probable this proportion will be found to be further lessened when the present small-bore rifle projectiles are used in war. But although this may prove to be a correct assumption as regards the narrow rifle bullets, there is no ground for anticipating that projectiles of irregular forms, such as fragments of shells and other secondary missiles, will become lodged less frequently than they have hitherto been; it may rather be expected, from the violence of the new bursting explosives, the increased number of fragments into which the shells are likely to be broken, and the greater force impressed upon them, that the instances of penetration and lodgment by such projectiles will be considerably increased in number.

When lodgment in the tissues of the body has happened, whether of bullets or of missiles of irregular shapes, the effects they may produce are usually very uncertain. In many instances lodged bullets cause more or less interference with some of the natural bodily movements, and give rise to pain which may last for life if they are not removed; but in exceptional cases, of which some instances have been mentioned in other parts of this work, they remain for long periods inert, without causing any noticeable inconvenience. Sometimes they remain quietly in the place to which they have been originally carried; sometimes they wander away, travelling between muscles and tendons and around bones, until they reach some part where the inconvenience caused by their presence becomes intolerable, or till their further progress is arrested by some natural impediment, or until, under the influence of what Hunter has called the 'instinctive provision in parts to remove themselves so as to bring extraneous bodies to the skin for their exit,'[1] they show signs of their presence at some part near the surface of the body, whence their extraction is accomplished with facility.

Effects on the cicatrisation of wounds.—The effects of the lodgment of foreign bodies during the early stages of gunshot wounds have been noticed when describing their primary complications. Occasionally, under favourable circumstances of complete rest and suitable treatment, a wound will become soundly healed notwithstanding a foreign body remains in it; but, more generally, its presence not merely delays, but altogether prevents complete cicatrisation. The parts surrounding the site of lodgment remain tumefied and tender. Not improbably some constitutional febrile disturbance is excited, more or less suppurative discharge continues from the original opening made by the projectile, while, without care and attention to ensure the escape of the discharge by this outlet, matter may accumulate, find its way in other directions, and give rise to distant abscess. At other times the

irritation will gradually subside, and the wound become closed, but only to reopen from time to time; while in others, again, complete healing will never take place, but the track of the projectile will become converted into a narrow sinus from which a serous oozing, varying from time to time in quantity, will continue for years.

The nature of the material lodged has less influence than its superficial qualities.—The degree of irritation caused by the presence of a foreign body seems to depend more upon its form and external qualities than upon its nature. If the foreign body be metallic and have a generally smooth and rounded surface, not angular, and be of moderate size, it matters not of what metal it consists. Lead, tin, iron, copper, and brass may be retained in certain situations in the body apparently with equal impunity. Examples of leaden bullets lodging in parts of the body for many years, generally in muscular or connective tissues, but sometimes in delicate viscera, without being changed themselves and without causing noticeable irritation, have occasionally occurred. When lodged among muscular tissues for long periods, the subjects of such unextracted missiles will sometimes say that they cause a certain amount of uneasiness on changes of weather, especially when the change is from dry to damp weather, but that the uneasiness is not enough to induce them to submit to operative interference for its relief. In April 1859 an iron canister-shot was removed from the supraspinous fossa of the right scapula of an invalid at Fort Pitt. The man had been wounded at Maharajpore in 1843, but stated he had not been inconvenienced in any respect by the presence of the shot until a short time before its removal.

Some foreign bodies, even when sharp-pointed, seem to be able to travel slowly through the body without exciting a painful degree of irritation in their course, if their surfaces are smooth and polished. The fact is well known that steel needles which have been swallowed may move slowly to distant parts of the body without giving rise to pain, without interfering with the functions of the organs traversed, and without injury to blood-vessels or nerves, until they reach the neighbourhood of the skin, when for the first time they make known the fact of their lodgment by the formation of an abscess. On being removed, they are usually found in the same state as when they were swallowed. In a similar way a bullet will sometimes travel away from the place of its first lodgment, and subsequently be discovered, long after the time of its first lodgment, by the appearance of a tumour in some distant situation. An abscess is diagnosed, and, on being opened, the foreign body is found within it.

My friend Sir A. D. Home removed a large brass button from a soldier by whom the lodgment of this foreign body had never

even been suspected. The man had received a large number of wounds at the battle of Balaclava, and was taken prisoner by the Russians. He subsequently returned to his regiment with all his wounds healed. After he had been for some time at duty he complained of a small tumour, which was hard and tender, near the right nipple. He had been wounded at Balaclava on the opposite side of the chest, near the left nipple, by a musket bullet, but he did not connect the swelling with that wound. The projectile had not penetrated deeply, and was removed after the action without difficulty. Dr. Home, however, suspecting that some foreign body might have been carried in by the bullet and be still lodging, cut down on the swelling, and there discovered a coat button. It was lying in a small encysted abscess, and retained its original bright surface. Up to a short time before the man made his complaint—a period of two years from the date of the original wound—the lodged button had not given the least indication of its presence. It was only after his return to military duty that the pressure of the man's belt set up the inflammation which led to its discovery.

The unchanged condition in which such foreign bodies are usually found after being extracted is in all probability mainly due to the fact of their having been excluded from the access of the air; had they been subjected to its influence while lying in the moist tissues of the body, chemical changes would have been induced which in some of the metals would certainly have prevented them from remaining inert.

Similar freedom from irritation is rarely witnessed when the lodged foreign body is porous or cellular in its substance, and has an irregular outline, sharp edges, or a rough surface. Splinters of wood, spiculæ of bone detached and driven into neighbouring tissues by the force of a bullet, tufts of hair or wool, shreds of cloth or cotton garments, seldom permit a wound in which they remain imbedded to become soundly healed. The aperture of the wound may close up for a time; but, if there be no other way of escape for such foreign bodies, they invariably lead to the wound opening again. Pieces of soldiers' woollen uniform clothing in particular are observed to act as local irritants. Repeated experience has proved the general rule, that, whatever time may elapse, so long as a fragment of the uniform remains in any part of a wound made by a projectile, so long it will never become soundly healed. A fistulous track, and a certain amount of purulent discharge from its aperture, will usually be maintained during the whole period of its lodgment. It is sometimes surprising to find how small a piece of cloth has sufficed to prevent the healing process from being perfected. This may be partly due to the fact that the woollen clothes worn by soldiers in the field have usually been saturated by perspiration, loaded with dust, and therefore

abound in particles of a septic description. An exceptional case has been recorded, in which a piece of a cloth trouser was carried by a shot into the interior of a knee-joint and did not prevent the wound from becoming closed. The patient in this instance had also suffered a compound fracture of the femur on the opposite side. He was a considerable time under treatment for this injury, and during this period the wound of the knee-joint became healed. Eventually complications ensued which led to the death of the patient, and it was then, on examination of the knee-joint, which was in a condition of anchylosis, that the fragment of cloth was discovered. Had, however, the patient survived, and been able to exercise the limb, it is at least doubtful whether the fragment of cloth would not then have caused irritation in its neighbourhood.

Dr. Neudörfer has attributed the deleterious action of such substances to the fact of their being of an organic nature. He regards lodged foreign bodies as comparatively innocuous or noxious according as they belong to the inorganic or organic kingdom. His views are that all changeable and putrescible bodies, as fragments of bone, wood, cotton, linen, or woollen cloth, when lodged, excite fermentation under the favourable conditions of air, warmth, and moisture in which they are placed, and so lead to the disintegration of the blood and humours of the tissues. Such special importance does Dr. Neudörfer attribute to the decomposable nature of lodged organic substances, that, while he maintains their presence to be injurious in all parts of the body on account of it, he considers them to be so dangerous to life in certain situations, as in the lungs, that, when the fact of their presence is established, no efforts should be spared to effect their extraction as a matter of vital necessity.[2]

Such an explanation hardly appears to be justified by observation. Pieces of woollen cloth, small coils of linen, have lodged at the bottom of sinuous tracks of wounds for years without showing evidence of structural alteration.[3] Few substances are less liable to be acted upon by the fluids among which they are placed when lodged in the tissues of the human body than hairs, yet nothing will more persistently act as a source of irritation than they will, even a small number of them, under such circumstances. Here again, as a general rule, no wound will become soundly healed until they are removed. A fragment of stone, glass, metal, or other inorganic substance, with rugged edges and sharp points, will exhibit no more tendency to remain lodged in the tissues of the human body with impunity than a fragment of wood or bone of similar outline and form.

It seems, therefore, that the circumstance of foreign bodies being capable of lodging in living tissues with comparative impunity, or otherwise, depends more upon conditions of substance,

form, and surface, than upon their nature, as to whether they are organic or inorganic.

The effect of movements of the parts in which foreign bodies are lodged.—The part of the organism in which the foreign body is lodged has necessarily a material influence on the effects of the lodgment. Different sets of symptoms may be expected according as it lodges in the substance of a muscle, in the connective tissue, among tendons, in bone, within the capsule of an articulation, in a serous cavity, or in any of the viscera of the body.

The amount and kind of movement which are natural to the structures implicated will often have a material influence in determining whether irritation is set up in the neighbourhood of a lodged foreign body, although of irregular form, or whether it remains unnoticed, as it were, by the tissues adjoining it. If it be lodged in a part where very little movement of the tissues immediately surrounding it occurs, even in such an organ as the spleen, it may rest quietly without creating any disturbance. I have before alluded to a case in which a small fragment of lead was torn away from a bullet during its passage through a part of the spinal column, and was driven into the surface of the spleen. According to the report written by Dr. Wilks at the time the post-mortem examination was made, no evidence was afforded of previous inflammation, or of any mischief whatever, having resulted from its presence in the situation named. The adhesions that had been set up in consequence of the damage done to neighbouring parts by the main part of the bullet had probably kept the foreign body quiet in the bed which it formed for itself in the capsule of the spleen. The splinter of lead was not heavy enough to excite irritation by pressure.

The movements to which foreign bodies are liable to be subjected, either under the influence of the general changes in posture of the body, movements of local or of organic actions, and their effects upon the structures among which the substances happen to be lying, must be taken into account in estimating the probable results of their lodgment, as well as their physical qualities. It may easily be understood that a hard material, like a metal bullet when it retains its original smooth surface, if moved, will affect the structures amid which it is lodged very differently from a yielding foreign body with a rough surface like a piece of woollen cloth, or one with sharp edges and points like a splinter of wood, distorted bullet, or fragment of stone. It seems, indeed, that it is to their qualities of surface and substance, combined with the amount of movement of the parts in which they happen to be placed, that the variations in the effects of lodged foreign bodies may principally be traced.

The irritating effects of movement of parts around a lodged

projectile or other foreign body are frequently witnessed. In some instances no suspicion of the lodgment of a foreign body will be excited while a wounded patient remains quiet in bed under treatment. His wound may become closed; but when he begins to take exercise, and the movements of the parts concerned in the wound become more unimpeded, or if any friction or jolting against the surfaces with which the foreign body is in contact occurs through transmitted impulses from without, pain may occur, pus collect, the wound reopen, and the presence of a foreign body then become sufficiently evident. Or the same effect may result in cases where a bullet has been lying quiet for years, when prolonged or violent exertion is taken, and a great deal of movement occurs among the parts around the projectile. An officer residing near Netley, who was wounded in 1813 at the battle of Vittoria, had a bullet lodged deeply in the spinal muscles for fifty-six years. He suffered from abscess in the back twelve times during this period at various intervals. On each occasion the abscess occurred after unusual exertion in riding, and generally became healed without trouble under rest and ordinary treatment. The last occasion was in 1869, and again happened after prolonged exercise on horseback. The bullet this time made its way to the surface and was removed.

Encystment and isolation of foreign bodies.—Whenever a foreign body, especially one presenting irregularities of surface or outline, however slight, remains lodged for a considerable time in some of the soft tissues of the body without exciting disturbance, it is always found to have become provided with a protecting envelope. Inflammatory lymph has been effused about its substance, and this, after some time has elapsed, has become gradually converted into a dense, membranous investment, shutting it off from direct contact with the organised structures around, and frequently, by its connections, restraining it from shifting its place of lodgment. The union between this adventitious capsule and the foreign body is sometimes exceedingly intimate, so much so that the separation of the one from the other in the operation of extracting a long-lodged foreign body is often a difficult proceeding. Prolongations of the capsule seem to have entered minute openings of the surface, if the body has been a spherical one, such as one of the old leaden bullets; or are wound around projecting or twisted parts of it, if it should happen to have been a harder projectile which has become deformed.

We may sometimes observe the tenacity with which a bullet is held by part of the inner wall of an old cyst, in museum preparations which have been preserved in alcohol. Part of the cyst being removed to show the lodged bullet, the latter, notwithstanding its weight, is still retained within the open cyst, solely by the connections which exist between the leaden projectile and what

remains of the capsule. Such is the case in some preparations in which the fact of a bullet having lodged for many years in a lung is shown. In a preparation of the kind which I examined many years ago, the encapsuled spherical bullet was situated near the periphery of the lung, and the pulmonary pleura in its immediate neighbourhood was firmly adherent to the opposite costal pleura. By these means movement of the bullet as well as of the part of the lung adjoining the lodged projectile, and consequent irritation from its presence, must have been reduced to a minimum, notwithstanding the general movements of the organ in respiration.

Certain foreign bodies become more readily encysted than others. Dense metallic bodies with polished surfaces seem to be particularly favourable for becoming enclosed in well-fitting capsules of dense fibro-cellular tissue; bodies with angular outlines and rough surfaces, on the contrary, very unfavourable to this process. Coarse woollen cloth and similar substances seem to exert some special counteracting influence that prevents them from becoming isolated and encapsuled by surrounding lymph, and this perhaps mainly accounts for wounds in which such foreign bodies continue lodged usually remaining unhealed.

Accidents to which lodged foreign bodies may give rise.— Although a foreign body, such as a bullet, may remain for many years in a state of quietude by means of its encapsuled condition or of its lodgment in some particular locality, a local injury, or even a deterioration in the state of general health of the person sufficient to cause a lessened power of resistance on the part of the tissues within which the foreign body is lodged, may speedily convert this condition of inactivity into one of active mischief. Baron Larrey has recorded a case which well illustrates how a bullet, passively lodged, may be suddenly turned into an agent of serious mischief by local injury. A soldier was wounded by a musket bullet in the left shoulder. The ball penetrated deeply, and could not be found. The wound after a time became cicatrised, as if no lodgment had occurred; but, no doubt, with limitation to movement from anchylosis, though this is not stated. No further inconvenience was experienced until thirty-six years afterwards, when the man met with a fall in Paris. The shoulder which had been wounded came into collision with the pavement. The fall was at once followed by acute inflammation, and soon afterwards by the formation of pus within the articulation. Amputation had to be performed at the shoulder-joint; and, on examination of the limb, the bullet was found enclosed in a cavity in the substance of the head of the humerus. No traces of disease could be detected as a result of the protracted lodgment of the projectile in the bone; so that there was good reason for believing it would have remained in the joint without exciting mischief as long as the patient had lived, had it not been for the accident of

his fall. Many examples of a corresponding nature might be quoted. A specimen exists in the Museum of Military Surgery at Netley in which the bone cavity in which a spherical bullet is lodged has a close, smooth surface. No other change in the bone is noticeable. The bullet had evidently been many years in the cancellated head of the humerus in which it is seen.

It is evident that the liability to such occurrences should weigh with surgeons when considering the subject of exploring for and extracting lodged foreign bodies.

Lodgment of gunpowder grains.—The fact that grains of unexploded gunpowder are propelled by the gases which result from the ignition of the grains that are exploded, and are thus caused to act upon objects near at hand as projectiles, has been referred to in a previous chapter. When ordinary black gunpowder is used with portable fire-arms for bursting charges or other like purposes, and particles of it, propelled in the manner described, strike an exposed surface of the body, a considerable proportion of them usually penetrate and remain lodged. They rarely lodge deeper, however, than in the substance of the true skin, but some occasionally penetrate the areolar tissue immediately beneath it. When a quantity of the powder happens to be fired near to the face and neck of a person in such a way that they are struck by the exploded gases, the skin is at first generally and deeply blackened. Part of this blackness is caused by a superficial deposit of very fine particles in the form of smoke, and admits of removal by simple sponging. A certain quantity of the powder in the form of dust is driven into the substance of the epidermis. The larger complete grains are forced more deeply into the substance of the papillary layer, and some of them perhaps into the areolar network of the corium beneath. If nothing be done to remove them earlier, in the course of three weeks or so, the time varying according to other circumstances accompanying the injury, the gunpowder dust, and such of the larger particles which have lodged in the superficial epidermal layers of the skin, will have come away, and with them the greater part of the black colour will have disappeared also. The grains which have penetrated the derma, or still more deeply than the derma, remain lodged, and, instead of a black colour, they present a more or less blue aspect. When once the epidermal layers are completely healed over them, these lodged grains do not cause any local inconvenience, though the nitre in the powder might *à priori* be expected to give rise to some smarting sensation. Although the face may be thickly studded with them, the patient is not aware of their presence so far as sensation is concerned. He cannot himself feel the grains of the powder by rubbing the surface, nor are they perceptible when the skin is touched by another person.

This was the case with a patient, Sergeant K., of the Royal Artillery, in whose face, perhaps, there were as many gunpowder grains permanently lodged as in any instance I ever met with. He was invalided from Mauritius for injuries resulting from a shell explosion. He was holding the shell, a 32-pounder, in his hands when it exploded, and was at the moment actually stooping over and examining it; yet marvellously he escaped with no other permanent injury than the loss of his right forearm, and of a thumb on the opposite side. His face was universally studded with coarse-looking grains of gunpowder, but neither I nor the patient could feel any sensation of roughness or irregularity when passing the hand over them. If it had not been for the special marking of the skin, there would not have been any indication of the presence of the lodged particles.

It is not easy to give a satisfactory explanation of the blue appearance of the lodged gunpowder grains. The blueness is always more conspicuous in cold weather, probably only because the surrounding skin is paler. Nothing can well be blacker than gunpowder itself, especially when moistened. Similar accidents will not of course occur with the new chemical explosives, though the skin may be stained in colour by some of the gases resulting from their explosion reaching the surface of an exposed part of the body.

CHAPTER II

ULTERIOR CONSEQUENCES OF GUNSHOT WOUNDS IN PARTICULAR ANATOMICAL STRUCTURES OF THE BODY

Cicatrices of gunshot wounds.—The cicatrix which results from the healing process after the passage of a bullet through the skin and soft subcutaneous tissues, presents marked features which usually remain conspicuous for the remainder of life. The larger the bullet the more stamped and typical are the marks presented by the scar; but in almost every instance of an entrance wound of a bullet through fleshy parts, the features presented by the resulting scar are so characteristic as to cause it to be quite distinguishable from the scar of a wound originating in any other source of injury. When a bullet has lodged superficially in a bone which is covered by little more than skin and fascia, there is not the same facility of recognising the origin of the scar. The depressed and adherent cicatrix which remains after the gunshot wound is healed is not distinguishable from the cicatrix left by any other lesion in which partial loss of bone substance has occurred in the same situation.

When a spherical bullet has entered any of the soft parts of the body in a straight line, or with only a moderate degree of obliquity, the cicatrix presented is sometimes circular, sometimes oval, with a defined margin, is slightly depressed, indicating loss of tissue, with a white film on the surface and a central ridge, often of a pink colour, towards which white cicatricial lines radiate from the somewhat elevated circumference. The cicatrix is more vascular, and therefore presents more of the pink colour at an early period after the wound is healed than it does later in life. If the bullet has entered with much obliquity, the depression of the cicatrix will be most marked at that part where the bullet has passed away into the deeper tissues. It will generally be pinker in colour at this situation, and the white cicatricial lines will converge towards it. Such a cicatrix will have a defined and even curvilinear margin bounding the part of it which is most depressed, while the surface of the cicatrix farthest away from the depressed portion will gradually fade into the general level of the skin.

But the most characteristic sign of the cicatrix being one of a gunshot wound will be the disappearance of some of the support which normally should exist beneath the surface at the part where the wound has been inflicted. The end of the finger, on being pressed against the cicatrix, sinks into a more or less obvious cavity. This is especially due to loss of substance, or to a split-like opening in the aponeurotic fascia, and to the fact of the skin toward the edge of the cicatrix being adherent to the margin of the opening in that structure.

Some modifications will result from the form of the surface of the part at which the ball has entered or the wound has been inflicted, the degree of firmness and thickness of the aponeurotic fascia beneath it, and the pliability of the skin ; but the general features previously described may always be expected to be present in a more or less notable degree. The action of muscles or other special organs near the wound, and the connections which the cicatrix may form with neighbouring parts, will also occasionally modify its appearance. A soldier of the 55th Regiment was wounded at the lower part of the neck in front by a bullet at the battle of Inkerman. When I examined this man in 1870, I found the cicatrix had acquired the shape and condition of a pouch, into which my finger could be inserted as into the finger of a glove. It was in front of the trachea, and went down to the depth of one inch and half behind and below the upper edge of the sternum. This had obviously been brought about by the natural movements of the trachea and chest. Sometimes the cicatrix, during the process of healing, becomes intimately connected with the fibres of a subjacent muscle or tendon, and the cicatrix is puckered and drawn in whatever direction either of these structures may happen

to be put into action. This traction gives rise to no particular inconvenience when the scar is a small one, but in extensive superficial wounds it is sometimes a source of pain and trouble.

The cicatrix of the wound of exit is generally strongly marked, but rarely presents the same circumscribed even outline, or cicatricial lines radiating from it with the same regularity that characterise the wound of entrance. It is generally less depressed, sometimes not at all so, while the opening in the fascia can seldom be felt so plainly as it can be at the wound of entrance. The end of the finger cannot be pressed inwards at the cicatrix in the same way. But so small are the cicatrices which result from wounds by the very narrow bullets of the present day, when only fleshy parts are concerned, that the features which distinguish the scars of the entrance and exit wounds of bullets of larger sizes are hardly, if at all, noticeable in them.

The irregularity in the general shape of the cicatrix of a wound of exit will be all the greater if bone has been fractured and the fragments driven by the projectile towards it. Such a cicatrix will usually be only partly adherent, and will be marked by central lines, somewhat raised, corresponding with the original lines of separation of the torn surface, and finer cicatricial lines from contraction, generally white in colour, radiating towards them.

The cicatrices resulting from wounds caused by fragments of shell vary in their dimensions and limits according to the size of the projectile by which each wound has been inflicted, the extent and depth to which sloughing has followed it, the situation of the wound, and other circumstances. The loss of substance with which such wounds are frequently accompanied, and the contractions which are formed in the process of healing, lead to much irregularity in the characters of the cicatrices, and the amount of deformity attending them. The contraction of such a cicatrix causes the tissues to be so drawn that there is always a tendency to ulceration in situations where it is exposed to friction or contusion, especially when the cicatricial integument is non-vascular, thin, and is tightly bound down to the parts beneath, or is liable to be suddenly and frequently put on the stretch. Such cicatrices often interfere with the normal functions of the parts implicated, and are apt to become the sites of chronic ulcers which are very difficult to heal, and very liable to open again whenever closed.

The cicatrices of burns from explosions of gunpowder differ only from burns of the same depth from other causes by a certain amount of fine particles and grains of gunpowder being usually lodged in the skin and subcutaneous tissues. The persistence of the colour arising from the lodgment of these particles of gunpowder, and their general characters and effects, have already been noticed.

In the majority of instances the cuticular cicatrix of a rifle-shot wound is quite free from pain or uneasiness after the first tenderness has passed away. There may not be the same acuteness of sensation as exists in the adjoining skin, but the space is small, and the difference so little marked, that it is not noticed. On the other hand, in some instances sensitiveness is increased, and remains so for many years, whenever the cicatrix happens to be touched. Sometimes scars are affected by changes in the state of the atmosphere, especially when a cold and damp state follows the opposite conditions. I have known men who were compelled to protect the scars of gunshot wounds from pressure in order to prevent the production of pain—in whom a firm pressure of the cicatrix gave rise to a startling 'burning and shooting' sensation, while a brush or light pressure of the part excited uneasy sensations of another kind, which were sometimes referred to the cicatrix itself, sometimes to distant parts. Obviously in these instances some nerve fibres had become involved in the cicatricial tissue, or, if not actually held by it, had become so disposed in regard to it as to be subjected to traction or pressure by its means under particular circumstances. Cicatricial connections with deeper organs may give rise to reflex irritation of remote parts. In one instance a man came under my notice who had been shot through the chest, and in his case the slightest pressure on the inverted and puckered cicatrix, which was in front of the chest, and evidently in direct communication by adhesions with the lung beneath, invariably produced a spasmodic cough which he was unable to restrain.

Remote effects of gunshot wounds on fasciæ.—The openings made by gunshot projectiles in the fascial coverings rarely become closed or filled up: probably never when they have been made by projectiles the forms of which have not been changed, and which have effected their passage while preserving a high rate of speed. I have examined a very large number of healed bullet wounds, and in all without exception the opening in the fascia at the wound of entrance has been traceable by a little manipulation. The edges of the fascial opening have become united to the margin of the opening in the skin, either wholly or in part, on the one side, and on the other to the cicatricial tissue by which the upper part of the track has become occluded. Thus it happens that, on pressing the finger into the superficial cicatrix marking the entrance of the bullet through the skin, the margin of the fascial opening can usually be readily felt.

In some cases the persistence of the opening in the aponeurotic fascia after gunshot wounds has led to muscular herniæ. In two instances which came under my notice, the muscular protrusions were in the leg, and were readily reducible. They took place from time to time when the muscles were put into action, and

then, after having been protruded, the protruding portions were liable, in certain other movements of the limbs, to become nipped by the edges of the tendinous openings, when a sharp pain would be the result. The protrusion in each case was easily returned when the muscle was relaxed, and its recurrence could be prevented by the pressure of a pad applied on the same principle as a truss for ordinary abdominal hernial protrusions. Similar muscular protusions could not occur under ordinary circumstances after wounds inflicted by small-bore rifle shot, owing to the small dimensions of their cicatrices, but may occasionally be met with after wounds by bullets of larger size and shell fragments.

Remote effects of gunshot wounds on the connective tissue.—The cicatrices of gunshot wounds, as regards the connective tissue, often interfere with the free action of neighbouring parts, and impair their functional qualities. This is chiefly due to the fact of the free and pliable fibro-cellular connective tissue being replaced by the compact fibrous tissue which constitutes the cicatrix. This structure, deprived as it is of lubrication and elasticity by the absence of fat cells and from its closer texture, unites itself to the parts adjoining by a number of bands of a similar nature. These parts thus become tied together and joined to the cicatrix of the wound, and so are hampered in all their movements. Such cicatrices never wholly disappear throughout life, but the restraint of movement becomes gradually lessened under the influence of constant use. The bands of adhesions become extended, and the parts thus acquire greater mobility. In some instances there is a total disappearance of the true connective tissue. Thus, when the cicatrix in the skin becomes adherent to bone, or a puckered inverted cicatrix has become closely united to muscle, the connective tissue originally existing between their respective structures does not form afresh, but they remain coherent for the remainder of life. The loss of connective tissue is often very marked in wounds which have continued to suppurate for a long time, or in which sloughing has occurred and extended to some distance beyond the direct track of the projectile. Under these circumstances the abnormal direct connections which have been formed between the adjoining structures unavoidably entail serious restrictions and diminution of power in the parts concerned.

The 'drag' of the parts held under restraint by these connecting cicatricial bands becomes a frequent source of aching and pain when neighbouring muscles are put into action, or when certain positions of the limb or part of the body in which the wound is situated have to be maintained for a considerable time.

Remote effects of gunshot injuries on muscles.—Gunshot contusions of muscular tissues, when severe, as from heavy fragments of shell, may lead to impairment of muscular function in several ways. Sometimes gradual wasting, without any other

marked symptom or evidence of lesion; sometimes paralysis, more or less complete; sometimes persistent pain, followed by wasting from disuse, result from such contusions. In other instances inflammatory action, with resulting contraction, or adhesions to neighbouring structures, becomes a source of impaired function. When an atrophic condition of muscles occurs, the loss of power which is a consequence of it is a source of disability and invaliding among soldiers. Muscular atrophy may also indirectly entail other lesions of a disabling nature. Thus atrophy of a portion of the muscular walls of the abdomen from severe gunshot contusion has occasionally given rise to ventral hernia.

Wounds of muscles by shot vary in their effects according to the extent of the wound, the situation and particular functions of the muscles wounded, and other like circumstances. The track of a small projectile through a muscle, when the wound has healed favourably, becomes closed by ordinary fibro-cellular cicatricial tissue. This usually remains intimately connected with the cicatricial material by which the openings in the other structures have also become repaired. After a time, varying in duration according to circumstances, the cicatrix of the track becomes more and more contracted, while its connections with the cicatricial tissues at the opposite surfaces of the muscle become elongated, and the muscle gradually regains greater freedom of action. So complete, under favourable circumstances, may this recovery of free movement become, that no noticeable restraint at last remains, and full power is regained.

Under other circumstances cicatrisation may so occur that this restoration of functional power may be wholly prevented. I have seen in an invalid the divided surfaces of the triceps brachii which had been severed by a shot a few inches above its insertion into the olecranon, remaining widely separated, and closely adherent to the humerus. The normal function of the muscle was thus wholly destroyed. Not only was all active power of extension of the forearm gone, but the power of flexion was prevented by the firm manner in which the ulna was fastened to the humerus, the short closely adherent lower part of the triceps admitting of no muscular movement. The arm was fixed in a position of nearly full extension; perhaps it had become so while efforts were being made to keep the separated ends of the divided extensor muscle in apposition. In the instance of a relative of mine who was wounded at one of the assaults of Sebastopol, the shot made a deep gap across the muscles of the front of the arm, and this gap was extended by the subsequent action of gangrene. Here the power of flexing the forearm towards the humerus was lost, but fortunately full mobility of the elbow-joint was retained, so that a slight artificial support of the forearm, such as its suspension by a ribbon carried round the neck, enables all the other move-

ments of the arm, including pronation and supination, as well as those of the hand and fingers, to be serviceably performed. In many such cases not only is the function of the wounded muscles destroyed, but anchylosis, partial or complete, of neighbouring joints takes place during the prolonged period of treatment, or as a result of the cicatricial contractions consequent upon the wound. The use of the whole limb then becomes seriously impaired. It is evident that all gunshot wounds in which muscles are completely divided across must lead to impairment, if not to loss of their function, the effects of which will be more or less serious according to their situation. The cessation of muscular power will not only entail loss of action in those parts on which they had been used to exert their influence under normal circumstances, but will generally induce changes in the condition of their opponent muscles. They become affected by the deprivation of the antagonistic action which had been previously exerted by the injured muscles. In some instances they will be caused to act inordinately, leading to more or less alteration in form of the parts with which they are connected; in others they will undergo a certain amount of wasting, and thus add to the general weakness already due to the state of the wounded muscles; while in others, again, they will become fixed, either in a state of flexion or extension, according to local circumstances, producing distortion and permanent impairment of function.

Remote effects of gunshot injuries on tendons.—The division of tendons, whether partial or complete, by gunshot is usually followed by impaired or destroyed functional power of the muscles to which they belong. The movements of the parts into which the tendons are inserted are impeded, or, it may be, completely lost. The union of the separated portions of the tendon itself is seldom, if ever, of such a nature as to allow the tendon to move with its full freedom again, while the healing process in the other wounded structures in the neighbourhood is rarely accomplished without creating further impediments to a return of normal action in the injured structures.

If the tendon be not completely divided, but only partially so; or if it be severely bruised, and is not afterwards destroyed by sloughing as a consequence of this contusion, the inflammatory action which is set up generally ends in fixation of it in its sheath, and in adhesion of the sheath to the neighbouring structures. The free play of the tendon is prevented, and not only loss of function, but more or less deformity generally results. If a tendon be completely divided, the end attached to the muscle to which it belongs retracts to a considerable distance, and in the process of repair usually becomes united to some of the adjoining structures, while the lower end becomes involved in the cicatricial tissue of the wound in the soft parts, or, if suitably situated, becomes adherent

to bone. In other instances both ends of the divided tendon become mixed up with the general cicatrix of the wound. The muscular function becomes very greatly impaired, or is entirely destroyed, and, of course, in the latter case the tendon ceases to exert any influence over the part into which it is inserted.

The function of a joint may be impaired or destroyed, as a consequence of the condition just named, of neighbouring tendons. Thus, I have seen in various instances some of the extensor tendons of the fingers divided at the back of the hand, and from the manner in which the lower divided ends have become united to the metacarpal bones, owing to the hands having been kept in a straight position on splints during the healing process, the fingers have become rigidly extended. Flexion could not be produced owing to the fixed state of the lower ends of the extensor tendons. Had the hand under like circumstances not been maintained in an extended posture, not improbably the function of the joints would have been equally lost, but permanent flexion would have been the condition presented.

Disabling effects of gunshot injuries to blood-vessels.—Contusions of arteries by missiles, although the lesions of the vessels may have led to their occlusion, and open wounds, whether the division has been partial or complete, when the immediate treatment of these injuries has been attended with successful results, do not as a rule lead to ulterior consequences of a disabling nature. The circulation, which has been arrested in the direction of the injured vessels, is in most cases adequately re-established through collateral branches, and no trouble is experienced, after the fresh distribution of the blood-supply is complete. In occasional instances when the injury has occurred in one of the limbs, as in the arm, and a main vessel, the axillary or brachial artery for example, is the subject of the lesion, the limb will never regain its full former strength, and there may be some loss of temperature, usually only observable, however, on critical examination. But judging from invaliding records, such cases rarely act as causes of discharge of men from military service unless they are accompanied by other sources of disability. Contusions and wounds of the larger veins are occasionally followed by permanent distension of the vessels at the seat of injury, sometimes by a tortuous and varicose condition of the venous system below it, together with the tendency to œdema and other disorders which are not infrequent consequences of interruption to the normal return of venous blood. In the majority of cases, however, when the injured vein is of moderate size, it becomes completely obliterated, and the return of blood takes place through other veins, either superficial or deep, with little or no permanent ill effects.

Disabling effects of gunshot injuries to nerves.—The ultimate consequences of contusions and wounds of nerves assume

many varied forms, and are often of a very distressing character. They are frequent sources of disability for military service among soldiers who have been wounded in action. Among the many resulting troubles following nerve injuries by projectiles are neuralgia, sometimes extremely acute, more or less persistent, sometimes disappearing with the lapse of time, sometimes lasting throughout life; severe cramps and shooting pains; impairment or total loss of power of motion or of sensation, or of both, in the parts supplied by the wounded nerves, sometimes involving a whole extremity; diminished temperature, alterations in colour, texture, and secretions, hyperæsthesia, liability to eruptions and ulcerations, and other nutritive changes in the surfaces of the parts supplied by the injured nerves, with shrinking of the deeper tissues; permanent flexion or extension of portions of the extremities, and stiffness of joints; paralysis agitans, increased under states of excitement; ganglion-like and painful enlargements at the site of injury, and other affections.

The power of sensation and motion is slowly recovered in some instances, perhaps after suffering severe pain in the course of the injured nerve; but, in other cases, in which the nature of the wound does not admit of the nerve continuity being restored, the paralysis remains unchanged throughout life.

Remote effects of gunshot injuries on bones.—The ulterior consequences of gunshot injuries of bones are sometimes persistently troublesome and painful: in some instances, notwithstanding that a limb in which fracture has occurred has been saved under conservative treatment and union of the damaged bone or bones consolidated, the disablement which remains, and the suffering entailed, are such as to make the patients regret that amputation had not been performed in the first instance. Shot contusions of bones, no less than fractures, lead to men being incapacitated for military service, and sometimes lead to consequences that are sources of more or less trouble for the remainder of their lives. The immediate effects of gunshot injuries of bones by no means in all cases indicate their total results.

Contusions of bones, especially of superficial bones, as those of the cranium, the chest, and of some parts of the two extremities, were frequent sources of remote troubles when the comparatively soft leaden bullets were in use. Similar contusions are likely to be exceptional occurrences in future wars. They can hardly happen with the modern small-bore rifle projectiles unless they have lost the greater part of their velocity before coming into collision with the bones under notice. In many cases where contusion of a bone has taken place, the injury done to the periosteum and to the bone itself is fully recovered from without any complication, and under favourable circumstances no ulterior bad results ensue. In other instances subperiosteal effusion of blood may be followed by

abscess, and exfoliation of a superficial layer of bone, and then closure succeed, which may or may not be permanent. In some cases a succession of sequestra will be separated, and the mischief be very prolonged. In others, ostitis, accompanied by much pain, may occur, and may either after a time subside under enforced rest and appropriate treatment, or lead to thickening and condensation of the injured bone, and to some of the other consequences of such inflammatory action. In a certain proportion of cases, some of the results mentioned may remain in a state of quietude for some years, and then be suddenly roused into action by accidental occurrences. Thus a certain amount of chronic thickening from periostitis or ostitis may last for years without pain and hardly any consciousness of impaired power; but under the effects of a lowered state of health, or under the influence of some accidental injury, a fresh accession of inflammation may be excited. This, under proper care and treatment, may again subside into a state of quiet, but is very liable under other circumstances to pass on to some one of the morbid conditions to which inflammation of weakened bone structures is apt to give rise—either necrosis, caries, or osteomyelitis. When the injury has occurred to a bone forming part of a joint, or to a bone which is near to one, the inflammation excited by it may have led to anchylosis, partial or complete. Not unfrequently the same result ensues from the effects of the continued restraint of limbs in splints, and consequent disuse of the joints, during the prolonged treatment of comminuted gunshot fractures of the shafts of bones, although the joints have been in no way involved in the original injury. Partial anchylosis often entails more trouble and suffering in its consequences than when it is complete, for fresh attacks of inflammation are easily excited by accidental falls or by blows on the impaired joints; and such patients have not the same facility of avoiding the effects of these injuries as persons in whom the corresponding members are in a healthy condition.

After a gunshot fracture has united, and muscular actions have been in a great measure restored, the bone remains more or less weakened for a very considerable time. Although continuity is regained, consolidation remains imperfect. Re-fracture is likely to take place if the bone under such circumstances be subjected to sudden strains, even to such as would produce hardly any injurious effect on the same bone in its normal state. An officer was wounded at Amoaful in the Ashanti war in January 1874. He sustained a severe fracture of the right humerus from a rifle shot. He rejoined the depôt of his regiment in September 1875, with the humerus apparently firmly united. One year afterwards, on the 15th of September 1876, nearly two years after the original wound, while riding, and holding the reins in the hand of the wounded side, a sudden jerk of the horse's head caused the

humerus to snap across near the old site of injury. A private of the 42nd Regiment also had his humerus fractured by a shot in the same action. The missile in this case came from one of the old smooth-bore muskets used by the natives, and the fracture was of a trifling nature compared with that sustained by the officer previously mentioned. The broken bone was quickly united, and seemed to be quite strong when the man landed in England in April of the same year. On the 18th of June he had a struggle with a prisoner, when re-fracture of the bone occurred at the former place of injury. A private of the 10th Regiment was wounded in action at Perak in the Malay Peninsula, on the 7th of November 1875. The right humerus was fractured. He returned to England in March 1876 with the bone apparently firmly united, but with the elbow, wrist, and finger joints almost completely anchylosed. In October 1876 an attempt was made to reduce the anchylosis of the elbow under chloroform, and while pressure was being made to bend the elbow, the humerus gave way and became broken again near the original wound. The re-fracture in these instances did not interfere in any way with a repetition of union.

Bones which have become firmly consolidated after gunshot comminuted fracture, and even in cases in which full power has seemed to have been restored, and in which the wounds in the soft parts have remained sound for years, are still liable to elimination of sequestra when detached splinters have been locked up in the new bone at the site of injury. I have elsewhere referred to the case of an officer who was under my care in the Crimea for a gunshot fracture of the thigh-bone in the upper third of the femur, who, though he had been on active duty and quite well for a period of nearly eleven years, suddenly at the end of that time became the subject of tenderness, without any external exciting cause, near the scar at the spot where the bullet had entered. The soreness increased, was followed by a small abscess, and from this abscess, when opened, a small sequestrum, one inch in length, evidently one of the original splinters, was extracted.[4] The wound of escape healed as soon as the piece of bone was got rid of, and no further trouble has been since experienced. Many examples of splinters locked up in the copious irregularly shaped new bone, by which some of the specimens of gunshot fractures have been united, are to be seen in the Museum at Netley. An examination of them will sufficiently show that such of them as by their form and situation were evidently completely detached at the time of the original injury are entirely necrosed; while others which had probably retained some amount of periosteal connection are also partially necrosed to a greater or less extent. As long as such fragments remain locked up in the new bony material, so long must the patient be liable to accidents connected

with them. Of these, the most favourable will be the occasional setting free of one or other of the fragments, its march to the surface, and final expulsion through the usual process of sequestral elimination. But under other circumstances the same series of unfavourable conditions may arise, which are apt to attend the presence of such inert substances as leaden or iron projectiles, when they are lodged in bone and subjected to disturbance. Many instances have been recorded in which such extraneous objects have remained dormant in bone for long periods of time, when an accidental violent injury has set up inflammatory action in their neighbourhood, and this has been followed by acute pain, abscess, constitutional irritation, and other ulterior results, sometimes of the gravest description.

CHAPTER III

ULTERIOR CONSEQUENCES OF GUNSHOT INJURIES IN PARTICULAR BODILY REGIONS

THE remote consequences of a gunshot wound in any particular region or anatomical system can only be properly estimated, so far as concerns an individual case, when the primary effects of the injury and the result of its treatment have been declared. But the general results of injuries, according to their situation in special regions of the body, and particularly those results which, as shown by experience, frequently lead to soldiers being disabled for further service, may be recapitulated without difficulty. A notice of them will sometimes point to ill effects which may be advantageously remembered, with a view to their mitigation and prevention as far as practicable, when wounds and injuries of a similar nature are in the course of their primary treatment. For this purpose I will refer principally to the disabilities which have been noted among the men discharged from the service at the general invaliding hospitals at Chatham and Netley for the effects of gunshot injuries. A considerable proportion of these invalids have passed under my own observation.

Disabling consequences of gunshot injuries of the head.—There are few cases of gunshot injuries of the head, whether contusions or contused wounds, and with or without fracture, which do not entail among their ultimate consequences some kind of cerebral disturbance. The little depth of the superficial coverings of the cranium, together with the contiguity and connections of the cranial contents, sufficiently explain the fact. These consequences are usually rendered more apparent in hot than in temperate climates. Numerous instances have occurred

among the invalids at Fort Pitt and Netley of men who were able to perform their duties in the ranks fairly well while in England, but who were found unable to continue at duty after they had moved with their regiments for service in India. The whole brain, as an organ, appears to be weakened after a sharp gunshot injury, for, as a general rule, it is rendered less able after one to bear any species of excitement that stimulates the cerebral circulation to increased action.

Wounds of the head, from the direct effects of which patients have recovered, leave behind them external marks which in many instances sufficiently indicate the nature of the injuries which have been inflicted. Not to mention scars from furrowed wounds limited to the scalp, others consist of cicatrices, often very irregular and extensive, adherent to bone beneath, but without alteration of the cranial outline; of cicatrices accompanied with more or less depression from loss of substance, when portions of the outer table, or of both tables of cranial bones, have been removed by the shot or subsequently by necrosis; and, lastly, of cicatrices with depression from fragments of bone having been driven inwards. Glancing wounds about the temporal region are occasionally followed by permanent dysecæa or complete deafness, perhaps with loss of a portion of the external ear, or with obliteration of the auditory canal in the cicatrix. Persistent cerebral disorder of less or greater intensity is usually met with in all these cases. Not unfrequently in some of the invalids there remains an expression of anxiety in the features of the face, or one of dulness and hebetude, which is very characteristic of cerebral trouble and incompetence.

When a portion of a cranial bone has been completely carried away, whether by the direct impact of the projectile or by the results of necrosis, the loss is not naturally repaired by the formation of new bone. A tough cicatricial membranous tissue, representing the integuments and the dura mater in close combination, is presented, varying in thickness in different cases, and this occupies the place of the bone that has been lost. If the membranous cicatrix is of considerable dimensions, some protecting cover has to be permanently worn over it as a safeguard against accidental injury. Not unfrequently this membrane may be seen to move with the movements of the brain. These movements are more obvious if some fluid, as when the parts are bathed, is allowed to lie in the depressed cicatrix.

The manner in which the cerebral disturbance is manifested varies very greatly in different instances. Headache is one of the most common symptoms, and this is sometimes intermittent, sometimes continuous. It varies in degree in different cases — from occasional pains of the most intense character to merely slight uneasiness. The injury to the brain may also exhibit

its effects in weakness, or loss of function, of one or more of the organs of hearing, sight, smell, and speech; or in simply diminished muscular power and sensory acuteness; in functional spasms; in dizziness on turning the head downwards or in stooping; or in more or less complete paralysis of the face or particular muscles, hemiplegia or paraplegia, or general paralysis. Epilepsy or convulsions of an epileptiform character are developed in some instances. Such seizures may, however, cease if an exciting cause can be discovered and removed. There are in the Museum at Netley the parts of a rifle bullet and some small fragments of bone which were removed from the interior of the lateral ventricle of a soldier wounded in the head, who had long suffered from attacks of the kind; the seizures gradually stopped after the extraction of the foreign bodies from the brain. And in an invalid at Netley who had been long suffering from the chronic effects of a cranial gunshot wound, epileptiform convulsions of extreme severity were stopped by the removal of a minute piece of bone, about the size of a grain of wheat, which was exerting pressure within a small opening in the dura mater. In other cases lessened mental power and intellectual activity are manifested, evidenced by defective memory, dulness of apprehension, depression of spirits without due cause, difficulty in forming and slowness in expressing ideas, and inability to fix or concentrate thought on subjects. The temperament of the individual is sometimes changed. The development of an excitable disposition is a common result. Slight causes produce irritation, and not unfrequently paroxysms of anger, in persons who were previously of a comparatively calm and easy temper. More or less loss of self-control is usually marked in such cases. In one case, an officer, with whom I was intimately acquainted, of thoughtful and rather reticent habits, after a severe contusion, became conspicuous for his talkative disposition and tendency to risibility on occasions when there appeared to be little to excite laughter. In this instance the injury was received on the vertex, but there was no open wound. In the early period of the case there was some suspicion that a fracture of the base of the skull might have occurred.

The brain, through the nerves connected with it, is rendered inordinately sensitive. Over-stimulation of the organs of hearing by excessive noise, of the eyes by bright dazzling light, or disturbance of sight by rapid cross movements of objects, cause cerebral uneasiness, and generally more or less mental bewilderment. Hence the brightness of objects in tropical countries, no less than the solar heat, cannot be so well tolerated as it may have been before the injury. Anything that interferes with the freedom and regularity of the general circulation, and so increases the impulse or disturbs the circulation of blood within the head,

speedily produces exaggerated cerebral excitement. Constipation, fatigue, anxiety, pressure of business, speedily give rise to confusion of ideas and headache. The use of stimulants in a similar manner leads to very deleterious effects. The amount of alcoholic stimulant that could be taken before the wound with impunity, if now taken, speedily produces evidence of intoxication, such as loss of muscular control, and not unfrequently induces violent outbreaks of ill-temper or delirium, and this condition generally continues during the remainder of life. Tight pressure about the head is ill borne, because it tends to impede the freedom of return of venous blood from the surface, and to produce more or less internal congestion.

In the few exceptional instances of men who have recovered after bullets have passed completely through the cranium and brain,[5] the consecutive disabilities of a permanent nature have presented wide variations, both in kind and degree. It is scarcely possible that any such case can happen among soldiers, without permanent cerebral disturbance occurring to an extent to prevent the man from earning a livelihood. The most prominent disabilities will be loss of mental power, particularly in general intelligence, judgment, or the faculty of memory, impairment of some of the sensory functions, or disorders of motion or sensation. The sense of sight has been totally lost by a transverse passage through the cranium of a bullet without any other persistent disability. Major H., of the 90th Light Infantry, who was for a long time a patient at Netley, was wounded in action at Kambulla Hill, South Africa, in March 1879, by a bullet which entered at the right temple and passed out at the left temple, one inch posterior to the outer angular process of the corresponding orbit on each side. Both optic nerves were destroyed by the bullet in its passage, and sight was at once and for ever extinguished. Major H. recovered completely in all other respects—hearing and all other senses, as well as intelligence, being quite unimpaired. The occurrence of the wound itself remained a perfect blank in his recollection; but every incident of the action, up to the moment of its infliction, was clearly remembered.

Disabling results of gunshot injuries of the face.—As gunshot wounds of the face are only followed by fatal results in a relatively small proportion of their number, their remote consequences may be frequently seen among military invalids who have been the subjects of them. One of the most noticeable effects of wounds of this region after cicatrisation is the alteration and deformity of features which they often leave behind them. Such disfigurements are generally very conspicuous and often distressing, if the wounds have been severe; occasionally, when they have been caused by fragments of shell and are extensive, they present a

hideous and truly repulsive aspect. As even most extensive wounds of the face can be undergone without fatal results, these very sad cases have hitherto been by no means rare in the hospitals to which military invalids are sent. So far as facial wounds from the projectiles of portable fire-arms are concerned, these mutilations are not likely often to result when small-bore rifles are in general use—their small dimensions and other qualities are sufficiently calculated to prevent such extensive disfigurements. Instances of facial deformities have been increased in number by the fact that the region of the face is that which most frequently suffers in cases of attempted but unsuccessful suicide by fire-arms among soldiers. In both polemical and suicidal wounds, important features of the face—the eye and eyelids, the nose, parts of the cheeks, the lips, and of the bones of the face, including the lower jaw—may be more or less shot away, or may become detached by the after-effects of the injuries to which they have been subjected, and their functions proportionately impaired. The deformities and disabilities produced by these ablations are in many instances aggravated by the changes and contractions which take place during the process of cicatrisation, and the bridling influence exerted by cicatricial bands on parts not directly concerned in the wound though adjoining it, especially on the upper part of the neck. The natural expressions of all the features of the face are perverted in such cases, and not unfrequently a horribly mutilated and meaningless spectacle is presented instead. Men are sometimes rendered so repulsive in appearance from mutilations in this region that they find a difficulty in getting employment in civil life after their discharge from military service, and in other ways suffer from their objectionable aspect. In awarding pensions to soldiers who have been subjected to injuries of this nature in active service, these circumstances ought always to be taken into account.

In a few instances such deformities assume almost a grotesque character. In the case of one patient who had attempted suicide, the whole of one side of the face was mutilated, while the other was quite intact. On the mutilated side, the globe of the eye, the lower part of the orbit, and a great part of the cheek were gone, an opening in the cicatricial tissue led into the mouth through a gap in the upper maxillary bone, and the soft coverings over the lower maxilla were extensively lacerated. The view of the man in profile on the one side being perfectly normal, a spectator was quite unprepared for the horrible deformity presented when the other side was suddenly turned to him. In another case, also one of attempted suicide, half of the upper lip had been torn away from its connections, and had become united upwards towards the orbit in a line with the nose. The hair continued to grow as it had done when the lip was in its normal place. A huge gap, left by

the loss of the eye, the lower part of the orbit, the malar bone, and a large portion of the upper maxilla, was covered over by a plastic operation; but the lip could not be wholly returned to its normal position, and the hair still grew in this situation.

Worse even than the lamentable condition to which such patients are reduced by the effects of their wounds in regard to personal appearance, is the permanent loss of power of usefulness, enjoyment, and of general health, which they sometimes sustain from injury or destruction of some of the important organs connected with the region of the face. Dimness of vision, or complete loss of sight from direct wounds as the effects of concussion in one or both eyes; more or less injury of the bony orbit and ocular appendages, with resulting visual disorders, obliteration of lachrymal ducts, ectropium, &c.; dulness of hearing or complete deafness, on one or both sides, from wounds involving the opening of the Eustachian tube, from wounds of the external ear and meatus, and obliteration of the cavity by cicatrices; disfigurement from crush or ablation of the nose; loss of sense of smell; impairment or loss of power of speech, from wounds and cicatricial deviations of the tongue, destruction of the palate, &c.; defectiveness of articulation and pronunciation, from distortion or destruction of the upper dental arch, from loss of teeth, from partial loss or retractions of the lips; impairment of mastication, or total inability to masticate from loss of teeth; restraint of movement in the temporo-maxillary articulation, or its complete fixation, from anchylosis; limitation of movements of the lower jaw as a result of fracture, or in consequence of cicatricial adhesions; loss of correlation between the upper and lower dental arches, so that they cannot be brought opposite to each other, from ununited or irregularly united fractures of the lower jaw, &c.; interference with freedom of deglutition, from ablation of supporting structures and muscular deficiency, from cicatrices, openings of communication between the mouth and nasal fossæ, &c.; fistulous openings and loss of power of retaining the salivary secretions; fractures of various kinds of some of the bones of the face; loss of power of action in the facial muscles near the site of injury; facial neuralgia;—all these serious disabilities have resulted from gunshot wounds in the face, and may exist, either separately or combined, in a greater or less degree, according to the extent of the structures which have been involved in the original injury. In some wounds of this region, not only the part directly wounded suffers, but other parts associated with it, though not struck, are indirectly, or eventually become affected by the injury which has been inflicted. An eye wounded by a projectile will very often cause morbid irritation, and ultimately impaired, if not complete, loss of sight in the remaining eye. With some of the consequences previously mentioned, impairment of the function of digestion is almost necessarily asso-

ciated; so that deterioration of general health may then be reckoned as one of the ultimate results of these wounds.

Wounds of the face, owing to the anatomical relations of this region, are sometimes associated with injuries to the base of the cranium, and thus some of the ultimate effects of injuries of the head are added to those peculiar to the region of the face itself. Even in cases where the facial lesion does not amount to a source of disability in itself, the effect of the cerebral concussion and disorder with which it was accompanied may be felt throughout life, sometimes becoming worse as time advances, and in the instances of soldiers may ultimately cause their discharge from the service. Such was the result of an injury, happily of an unusual kind, in the case of Private J. M'C., who suffered from a severe contusion of the right side of the face, together with a superficial wound which extended to the lower part of his right ear. He was struck at the final assault of Sebastopol by a man's leg that had been carried off by a round shot. Insensibility lasting for several days, and disturbance of mental faculties, followed the injury. He recovered, so far as the injury to the face was concerned, with the exception of deafness in the right ear, owing to the external meatus becoming occluded by cicatricial tissue, and in February 1856 he was sent to his regimental depôt. He remained at regimental duty for eleven years, subject, however, to frequently repeated attacks of giddiness, and always showing a certain amount of unsteadiness in the ranks. These symptoms increased in severity to such an extent on the man being sent to India that he was rendered unfit for his duties, and on this account he was discharged from further service.

The deformities from wounds of the face may sometimes be partially rectified by suitable plastic operations, or masked by prothetic appliances, and in some instances functional impairments may be lessened. In other cases artificial substitutes for parts which have been destroyed, such as the nose or an eye, may be employed for counteracting disfigurement with advantage. Such remedial measures, however they may be applied, can only be expected to act as very imperfect substitutes for the natural parts which have been impaired or destroyed. Many ingenious contrivances were devised to replace deficiencies in parts of the upper maxilla and hard palate, and of portions of the lower jaw, among invalids at Fort Pitt after the Crimean war. Some of these substitutes for the lost natural parts did not only lessen the unsightly appearance of the men concerned, but they added to their power of mastication, deglutition, and articulation, thus increasing their means of preserving health, earning support, and so promoting their comfort. M. Legouest has recorded the cases, and has given drawings of some men at the Hôtel des Invalides at Paris, who survived many years after loss of the entire lower

jaw and floor of the mouth, which had been carried away by grape or massive gunshot. Their condition was rendered less intolerable by the use of a metallic chin and plate for supporting the tongue, and by masking the full extent of their deformity.

Disabling results of gunshot injuries of the neck.—Wounds of this region which escape a fatal termination, especially those which are caused by somewhat large fragments of shells, often leave behind them contortions and restricted movements of the neck, and also in some instances forced inflexions of the head from the loss of substance and cicatricial contractions to which they give rise. These effects vary in amount and persistency according to the extent and situation of the cicatrices; but though the restriction of movement is usually lessened with time, full freedom is rarely ever regained. Extensively lacerated wounds being generally fatal when they are inflicted in the anterior part of the neck, it is chiefly after wounds of the posterior or sterno-mastoid muscles that such ultimate effects are met with.

Both contusions and wounds of the lower and lateral parts of the neck may be attended with injury to the cervical nerves; so that paralysis of motion and sensation, atrophy, contractions, neuralgic pains, and other results of nerve lesions, may be manifested in the upper extremity on the side corresponding with that of the injury, and remain permanent consequences of gunshot wounds of the neck. Still more extensive paralysis as a result of severe injury to some of the cervical vertebræ, with concussion of the spinal cord, and even, in a few rare instances, the effects of fractures of parts of some of the vertebræ, have been recorded as persistent consequences of wounds of this region.

Fistulous openings have sometimes remained when the larynx has been wounded, or the trachea penetrated without fatal results; and when such an opening could not be closed by a plastic operation, the permanent use of a cannula has become necessary. The usual consequences of tracheotomy and laryngotomy have persisted in cases where these operations have been performed in consequence of some of the primary effects of wounds implicating the larynx, and the patients have otherwise recovered. Aphonia may remain as the permanent result of a wound of the neck with simple contusion of the larynx. A young lieutenant who was under my care after having been shot from side to side through the œsophagus in the Crimea, recovered very favourably in all respects, with the exception of impaired vocal power. The bullet had evidently glanced against the posterior aspect of the larynx in its passage through the neck. It was hoped that this impairment might be lessened in time; but it was not, and he was eventually compelled, on rising to a higher rank, to quit the army solely in consequence of his inability to make himself heard at a sufficient distance. Many examples of deflection of projec-

tiles which have struck against the anterior aspect of the larynx have been recorded, and these have generally been followed by persistent aphonia. Irritable cough and difficulty of respiration are other consequences occasionally met with as permanent results of injuries of the larynx and parts associated with this organ.

Disabling results of gunshot wounds of the chest.—As wounds in which the cavity of the chest has been penetrated, and particularly those in which the visceral contents of the cavity have been involved in the lesion, have hitherto been attended with fatal results in a very large majority of instances, either on the field of action itself, or within a few days after admission into hospital, the ulterior effects of chest injuries have been chiefly observed in those of the parietal or non-penetrating class. The survivals among patients who have been subjected to penetrating wounds of the chest will probably occur in a much larger proportion in future wars. This may be expected especially in wounds inflicted by the new rifle bullets. The slight resistance that can be offered against their passage when they are armed with their average force will cause perforating wounds of this region to occur in far larger numbers; it may fairly be expected that more men will be struck, and there will be a greater proportionate number of penetrating wounds to non-penetrating wounds of this region than has hitherto occurred in war; while the narrowness and other physical qualities of the new projectiles, it may be hoped, at the distances at which men are likely to be wounded by them in war, will render their effects less fatal by limiting the areas of the lesions inflicted by them. For these reasons such cases will probably come under hospital treatment far more frequently than has hitherto happened.

In many instances in which men have suffered a shot contusion of the chest without any open wound or injury to bone, whether by a fragment of shell, a bullet at high speed which has struck some resisting object, as a watch, coins, &c., or by a bullet at lowered speed, although there may at first have been signs of injury to a lung, such as hæmoptysis or painful dyspnœa. recovery after a time is almost complete. No ulterior consequences of a disabling kind remain. In other instances the ultimate issues are not so fortunate. The local contusion has been more severe, the commotion of the lung greater, there may have been laceration of the pulmonic substance, vessels ruptured, and as consequences, after these primary lesions have been repaired, there may remain pleuritic thickening and adhesions, permanently restrained movements of the chest-walls, with troubled respiration on any unusual or prolonged exertion. Cicatrices, with tendency to ulceration if pressed upon, or with contractions that permanently interfere with the full freedom of the chest-walls and adjoining arms, are among the disabilities occasionally met with in consequence

of diffused or burrowing abscesses, sloughing and loss of substance. If the gunshot contusion should have been attended with fracture of some of the bones composing the frame of the chest—the sternum, ribs, scapula, or clavicle—other elements of disability are introduced. The varying kinds and degrees of the ulterior effects due to these complications depend on the circumstances of each particular injury and the immediate sequels of them—the inflammatory troubles to which they give rise, and the surgical proceedings which they render necessary in certain instances for their relief. It rarely happens that shot contusions of the chest with fracture of a bone are so completely rectified as not to leave any ulterior infirmity behind them, or incapacity for military service. A man after such a wound may recover so that he can get on without special inconvenience in some civil pursuit so long as the movements of his chest are not hampered by any restraints. If put to ordinary military duties, he would not be able to bear the constriction of his uniform tight clothing or belts across the chest; he would complain of uneasiness from their pressure, as well as of oppressed breathing. If the scapula or clavicle be the bone fractured, the arm in connection with the damaged bone is often left more or less powerless and painful, from stiffness of the shoulder, muscular atrophy, anchylosis of the shoulder-joint, or injury to brachial nerves.

When a projectile has not only contused, but has also caused an open wound in the parietes, although it may have only glanced across or have injured a rib or other bone, without entering the pleural cavity, other sources of ulterior disability arise. Suppuration generally occurs, and the injury to the bone, especially if it be caused by a jagged projectile such as a fragment of shell, usually entails necrosis and elimination of sequestra or particles of bone, and this process is often prolonged for years. Even after healing is accomplished, adherent cicatrices are left behind, which either from their position, extent, or proneness to ulcerate, generally incapacitate men for military service. Moreover the concomitant inflammatory changes within the chest in such cases usually lead to more or less interference with the freedom of respiration which is essential for the due fulfilment of military duties, and not unfrequently become sources of cardiac trouble and bronchial irritation.

Several disabling complications are liable to occur, when not only the cavity of the chest has been penetrated, but a lung also wounded. A certain proportion of men escape, notwithstanding the usually fatal character of such wounds; and some have survived although such complications have occurred as the projection of fragments of a broken rib or piece of clothing into the lung, or the lodgment of the projectile itself in the cavity of the chest. Some of these complications may, and probably will be, rare from

rifle bullets in future wars. A small-bore bullet may often enter through an intercostal space without touching a rib, although, if it perforate the chest, as it will probably do, it is very likely to strike a rib in making its exit; the velocity with which it flies will prevent it from lodging within the cavity; and the smallness of the opening made by it in articles of clothing—sometimes a minute narrow slit—will obviate much of the risk of such foreign bodies as fragments of linen or cloth being carried into the lung by it. But even without these complications a penetrating shot wound of a lung must always produce effects which will permanently disable a soldier for military service. There were several men invalided at Netley in 1883 after having undergone perforating wounds of the chest, with lung lesion, from rifle bullets in Egypt in 1882. They had fully recovered from all the primary effects of their wounds. The wounds of entrance and exit, and, as far as could be traced, the lung wounds, were soundly healed. But they all suffered from dyspnœa and palpitation on exertion, and in two of them, in addition, there was deficiency of the normal movements of an arm, originating in one instance in cicatricial contractions, and in the other from injury of nerves of the axillary plexus by the bullet in making its exit.[6]

Although instances have occurred of a foreign body, such as a bullet, having remained lodged in a lung for many years with comparative impunity, other foreign bodies, such as pieces of bone or cloth, as the histories of cases show, usually act as sources of continued irritation, and sometimes of danger, as long as their presence is maintained. The following will serve as examples. Captain K., R.A., received a perforating bullet wound of the chest at Delhi in 1857. Ribs were fractured at both openings of entrance and exit. The bullet lodged beneath the scapula, whence it was excised. Hæmoptysis recurred almost daily for two years. By the end of the third year, though still suffering, he was sufficiently recovered to have the command of a battery. In 1865, after calling out loudly on parade, severe hæmorrhage recurred, and he then had to retire from the service altogether. It was believed that some foreign substance, probably a small fragment of bone, escaped on this occasion. The hæmorrhage ceased after a few days and did not return, but he remained an invalid, and in 1886, when I last saw Colonel K., he was weak and emaciated, still suffered from dyspnœa, was very susceptible to atmospheric changes, and had the aspect of a man twenty years older than he then was. Another patient who had received a perforating bullet wound in India, and in whom also ribs in front and behind had been fractured, died at the Invalid Hospital at Chatham from disease unconnected with his wound. The fractured ribs were consolidated, the entrance wound completely healed, but a very narrow sinus, from which a slight discharge exuded, occupied the site of

the wound of exit. On inspection after death, some small spicula of bone and a small coil of linen, which were lodged a short distance from the wound of exit, were discovered to be the source of this persistent conduit. In the Surgical History of the United States War of the rebellion it is recorded that fistulous openings existed in the pectoral parietes of twenty-two invalids on the pension rolls, who had suffered penetrating wounds of the chest. The failure of the pleura to adhere near the orifice after puncture of the chest-wall for discharge of empyema is referred to as one of the sources of this complication.[7] The development of phthisical disease has been included among the remote effects of penetrating wounds of the chest; but the cough, expectoration, wasting, and irritative fever present in cases in which the symptoms have been attributed to consumption have probably been due to other causes. The experience afforded by the United States war was enormous, and Dr. Otis has recorded that none of the autopsies appeared to establish any relation for good or evil between wounds of the chest and true tubercular phthisis.

Disabling results of gunshot injuries of the abdomen.—The larger proportion of invalids who survive to be disabled by the results of gunshot injuries of the abdomen consist, as might be anticipated, of men who have suffered injuries chiefly confined to the parietes. This will probably remain so in future wars, although, instead of being inflicted in about equal proportions, as parietal and penetrating wounds have hitherto usually been in battles, the penetrating wounds seem likely to become inflicted in larger proportion. The increased penetrative qualities of modern projectiles will cause the number of wounds of the abdomen in which the peritoneal cavity is opened and viscera wounded to become more frequent, while the difficulties in the way of applying the remarkable improvements that have taken place in abdominal surgery in civil life to military practice after important engagements in the field, will probably prevent any considerable reduction in the large ratio of mortality which has hitherto attended them. Thus observations on the ultimate disabling effects of gunshot injuries of this region will continue still to be chiefly limited to those of the non-penetrating division.

When a wound of the abdomen is inflicted by a rifle bullet, penetration of the cavity may not occur if the projectile happen to strike in a direction nearly parallel with the surface, or if its progress be stopped by collision with some hard substance, as the clasp of a man's waist-belt, or any accidental obstacle upon his person. So also the tangential or oblique direction followed by a fragment of shell of limited size may prevent penetration; or, if it be one of large size, it may so strike as to cause severe superficial contusion, with intra-muscular sanguineous effusion, with or without visceral contusion, or subcutaneous muscular rupture, or

laceration and removal of a portion of the parietes, and yet without opening the peritoneal cavity or inflicting visceral injury by actual contact. In all such cases disabilities of a permanent character may ensue, either at the time the injuries are inflicted, or after a cure of the direct effects of the injuries has been accomplished. Visceral protrusions may present themselves at the instant of impact of the projectile through some of the ordinary channels, or in other cases ventral hernia may follow wasting of a portion of the abdominal wall due to atrophic changes brought about by the contusion, or through actual loss of substance and of natural support by laceration and removal by the projectile of a portion of the muscular layers, or by extension of a parietal wound through sloughing. In some instances in which the loss of the abdominal wall has been very extensive and deep, such adhesions and cicatricial contractions may occur as seriously to impede the natural movements of the body or of an adjoining limb of the patient. The restraints and pain of such a condition constitute a permanent hindrance of useful or remunerative exertion. I had the opportunity of seeing frequently a very severe case of abdominal wound of this description in the Crimea, under the immediate care of my friend Civil Surgeon Rooke. A massive projectile had glanced across and torn away all the coverings of a space about five inches long and from three to four inches broad at the lower part of the abdomen down to the peritoneum. No direct injury had been done to any viscus. The bowel which was exposed to view in the gap did not exhibit any tendency to protrude. This patient recovered, notwithstanding that, in addition to his very grave abdominal wound and some sloughing which attended it, there was a comminuted fracture of the crest and body of the adjoining ilium, a wound of the thigh with injury to the upper part of the femur, and that his forearm on the same side, which had been crushed by the shot, had to be amputated. The loss of the abdominal wall was gradually repaired by granulation, as was also the wound of the ilium, the crest of which became separated by exfoliation; but when this man was discharged from the service at Chatham, six months after the date of the wound, the contractions connected with the extensive cicatrix, and its close adhesions to the ilium and upper part of the thigh, prevented all free movements of his body and lower extremity on the wounded side, and were sources of frequent pain. He was only able to move about with the aid of artificial supports. This may be regarded as an extreme case of the kind, but disabilities of a similar nature remain in all such cases in proportion to the extent and situation of the wounds concerned. In other instances of parietal contusions, abscesses occur between the abdominal muscular layers, and even after they, or sinuses which may have followed them, become healed, restriction of

certain bodily movements, and probably occasional pain, are resulting consequences. Some parietal contusions by shot are attended by bruising of deeper structures, and the injuries are followed by localised peritoneal inflammation, with more or less adhesions between the parietal layer, the omentum, and some of the adjoining viscera. Such occurrences are apt to become sources of constant uneasiness, and of occasional attacks of pain, while they generally cause interference with some of the normal processes of the function of digestion. The extent of disability attributable to the conditions mentioned will necessarily vary with the sites and limits of the adhesions which have taken place. The resulting effects may only occasionally assume a character of urgency, but, whatever their character may be, the patient will probably remain subject to them throughout life.

Penetrating wounds of the abdomen by shot or shell, in which parts of the walls have been carried away and the cavity exposed, and perforating wounds in the exceptional cases in which recovery takes place, are liable to be followed by various sources of disability for military service. They may leave behind them deep adherent cicatrices, which give rise to more or less inconvenience according to their position and extent, leading in some instances to a bent posture of the body, a fully erect gait being hardly possible, or possible only for a short time, and then with pain. If the cicatrix happen to be in either iliac region of the abdomen, it may entail permanent flexion of the thigh and abdomen towards each other, with, of course, impediment to easy progression in marching. Deeper visceral adhesions may cause pain in certain movements of the body, inability to bear tight pressure, as that of a waist-belt, irregular action of the bowels, constriction of intestine, obstipation, occasional attacks of enteralgia, and various dyspeptic symptoms. Hernial tumours are also among the occasional results of these open wounds as well as of the contusions before mentioned; and when the cicatrix has been large, thin, and yielding, as has happened after glancing penetrating wounds in this region, much difficulty has been experienced in preventing visceral protrusions from the cavity when coughing, in certain bodily movements, or in strains under muscular exertion, by any artificial appliance. Tenderness of the cicatrix, and liability to ulceration, often act as impediments to the use of ordinary trusses, however well fitted, when they press sufficiently to prevent protrusion altogether.

Cases in which not only the cavity of the abdomen has been penetrated, but some of its visceral contents wounded, are so generally fatal, that the instances in which soldiers have to be discharged from the service for the after-results of such wounds are very exceptional. Again, it is comparatively rare that a wound of a particular viscus can be isolated, for in all such injuries by projectiles it is usual for more than one viscus to be wounded.

Instances do occur, however, in which the symptoms of a wound of a particular viscus appear prominently, and in which, when recovery ensues, the after-results become the leading features in the disability of the invalid who has been the subject of it. Thus during the war of the Rebellion in the United States as many as 62 instances of recovery after gunshot wounds of the liver were reported to Washington, and of these 32 were regarded as wounds of this organ beyond all doubt.[8] The ultimate disabilities noted among the men invalided on account of these wounds were pain on movement, increased by laborious exertion pain on stooping and lifting weights, pain extending to the shoulder, imperfect movements of the right arm, and impaired digestion. In one Crimean case under my notice, not only the general health was deteriorated, but hepatic abscesses were formed at intervals during several years, and were discharged by the bowels. These occurrences led to the surmise that some foreign body, perhaps a fragment of some article of the man's clothing, had lodged in the organ, and acted as a source of irritation. In wounds in which the stomach has been involved, a permanent gastric fistula may result, as happened in the well-known case of Alexis San Martin. In an unequivocal case of recovery after a pistol-shot wound of the stomach during the United States war, the only permanent disability which resulted was flexion forwards of the body in consequence of cicatricial contractions in the direction followed by the bullet as it passed through the man's abdomen. Soldiers who survive after having been wounded in the kidney have usually been shot in the lumbar region, so that the cortical substance of the organ has been the part chiefly implicated in the injury. In such cases an urinary fistula may result, or, if this do not follow, there may persist after the wound is healed lumbar pain, increased on exposure or sharp exercise, impaired movements, or other troubles from cicatricial adhesions. Although 26 cases of recovery after wounds of the kidney during the United States war are reported in the history, any after-effects that might have remained are not detailed. Recoveries after gunshot wounds of the intestines are usually limited to wounds of the colon. In these instances an artificial anus has generally occurred in the early period of each case, which in time became reduced to the condition of a fæcal fistula. After a time, varying in duration, the fistula usually becomes closed, but in some instances fæcal fistulæ persist for years, and continue unhealed as long as the patient lives. In 59 instances of complete or partial recovery after shot wounds of the large intestine during the United States war, the resulting fæcal fistulæ became closed in 50 in periods varying from one month to four years, while in the remaining 9 they remained open. Although life is preserved in such cases, the condition of the invalids is most lamentable, and their dis-

ability for employment total. Even in patients in whom the stercoral fistula has become healed, either under simple treatment or after surgical operation, consequences usually remain which unfit the men for active work. For a long time strong bodily exertion is attended with the risk of causing the fistula to become reopened. Locomotion is often difficult. Some men complain of dragging pain and tenderness at the site of injury. A soldier who was wounded at Lucknow at the time of the Sepoy Mutiny, recovered so completely from the effects of a stercoral fistula connected with the descending colon that he was discharged to duty in the ranks. A few months subsequently he committed an offence for which he was subjected to the punishment of shot drill. The strain on the abdominal muscles in bending forward and lifting the heavy shot caused the artificial anus to reappear, and he had then to be discharged from further service.[9] But even if the parts have become so consolidated that the invalid is not exposed to such a danger from muscular efforts, other incapacitating disabilities may exist. A private of the Gordon Highlanders, wounded in 1882 at Tel-el-Kebir, recovered from a bullet wound in the left iliac fossa, followed by an artificial anus, so far that he was eventually discharged to duty. Some slight lameness and stiffness in walking, with occasional dragging pain after exertion and during defæcation, were alone complained of. He remained a short time at the depôt of his regiment, and was then considered fit by an inspecting surgeon to be sent to rejoin the headquarters at Cairo. He arrived at Cairo in May 1883. But in a very short time he was found incompetent to perform the ordinary regimental fatigues and duties. Even when transferred from the ranks to work in the tailor's shop, his trade having been that of a tailor before enlistment, it was found he could not do it, as the crossed position of the legs in which a tailor usually sits for work gave rise to so much pain. He was therefore invalided and sent back to England in June 1883, and discharged from the army. A cicatricial band could be felt in the left iliac region, and readily traced on examination from the cicatrix of the entrance wound to the sigmoid flexure of the colon.[10] In some instances after the closure of a stercoral fistula, a truss or supporting belt has had to be constantly worn, on account of muscular weakness or hernial protrusion.

Among the rare cases in which small projectiles have lodged in the cavity of the abdomen and the patients have survived, there do not seem to have been presented any particular permanent symptoms beyond those which are apt to accompany peritoneal adhesions consequent upon penetrating gunshot wounds without lodgment of foreign bodies. In the case of an officer who was wounded in India in 1858 during the Mutiny, and who died suddenly in 1865 at Portsmouth from strangulation and obstruc-

tion of the bowels, there had been no indication of the lodgment of the projectile, which was found after death in the right hypogastric region.[11] He had been treated every now and then for attacks of obstinate constipation, but had not complained of any other symptoms. In the year 1890 a groom in the employ of a gentleman residing near Netley accidentally fired a revolver bullet into his abdomen. The opening was direct, and the fact of penetration by the projectile, and of its lodgment within the cavity, was obvious. He was seen some days after the injury by the late Surgeon-Colonel Godwin. Peritonitis was then actively developed, and the case was regarded as beyond recovery. But the man survived, and some months afterwards appeared to be free from all ill effects of the wound; he was not conscious of any ill result from it. In several instances of invalids discharged from the service at Fort Pitt and Netley, the circumstances of the wounds have given grounds for suspecting lodgment in the cavity of the abdomen of the projectiles by which they had been caused, but no symptoms were presented that would enable the suspicions to be verified. It was presumed that in these instances the bullets had become encysted in positions where they were not subjected to pressure or movement.

Ulterior disabling effects of gunshot wounds of the back and spine.—Men who survive to be discharged from military service after having sustained gunshot injuries of the back and spine, vary greatly in condition as regards the remote effects of their wounds, according to the nature and complications of the lesions inflicted, and more especially according to the extent to which the spinal cord has been damaged, whether by commotion, compression by effused blood splinters of bone or missiles, by contusion, or by laceration. Simple flesh wounds of the back without direct spinal lesion merely entail such disabilities as depend on the loss of substance, cicatricial contractions, adhesions, and the impediments to free and easy movements of the body which may result from them according to their situation and extent. Special symptoms are added when bullets which have lodged deeply in the spinal muscles have remained unextracted. In cases in which the wounds have been inflicted by massive projectiles, and the laceration has been very considerable, the loss of substance is often increased by sloughing, and the resulting disability becomes very great. In instances of this kind the cicatrices have usually remained permanently tender, and much aching and pain, which properly adapted supporting belts have relieved, but have failed to remove, have accompanied the action of the muscles in the neighbourhood of the affected parts. Such extensive wounds, however, without violent commotion or contusion of the vertebral column near the situation of the wound, or fracture of some of the neighbouring spinal processes, must necessarily be very exceptional. As regards injuries of the spinal

column itself, the experience gained during the war of the rebellion in the United States, and during the Franco-German war, together show that about three-tenths of the men admitted into hospital with fractures of the spine survive to be discharged from the service. The cases recorded also indicate that the general pro portion of survivors is not very materially affected by the part of the spinal column which has been the subject of the lesion. Many patients survive in whom fracture has occurred, but which has been limited to the projecting spinous process, without deeper injury or other serious complication. In some instances of this description of fracture, although prolonged trouble has been caused by the elimination of sequestra before the healing of the wound has been completed, yet no permanent disability has eventually occurred. In the relatively fewer survivals after wounds in which the transverse processes have been fractured, the ultimate consequences have been of a graver character, for fractures of these apophyses can scarcely be effected by projectiles without violent commotion or contusion of the spinal cord, not to mention injuries of other adjoining structures. Hence various defects of sensibility and motility, according to the depth and position of the injury, are usually permanent in such cases, with more or less general debility and mental depression. In many such wounds, when they have been caused by small-arm projectiles, the bullets have remained lodged, and their removal only effected by surgical proceedings. Various instances of pensioners permanently disabled by more or less complete paralysis after wounds of the kind mentioned are recorded in the Surgical History of the United States War by Dr. Otis (vol. i. p. 459, &c.). Even when spinal gunshot injuries have been accompanied by distinct lesions of the cord, a certain proportion of the patients admitted to hospital survive, although the majority die. Among 54 traumatic cord lesions by shot recorded by Dr. Otis, 12 patients recovered sufficiently to be discharged from hospital, though with various degrees of disability. Nearly all the men discharged after severe spinal injuries are incapacitated for employment in civil life, and become dependent on the State for their livelihood.

Disabling results of gunshot injuries of organs of the genito-urinary system.—These embrace injuries of the scrotum, testes, and spermatic cord, penis, and urethra. Although a wound caused by a small projectile may be limited to the scrotum, to the scrotum and a single testis, or to the penis without lacerating the urethra, the general rule is that several of the parts mentioned are wounded together. When the wounds are inflicted by fragments of shell, not only are several of the organs named simultaneously wounded, but laceration of the perineum and other neighbouring parts usually occurs in addition. Rifle bullets also which have already traversed other parts, as when they have

entered and passed through a natis from behind, or when they have travelled laterally through the upper parts of the thighs, are very apt to wound some of the organs of the genito-urinary system before they make their final escape from the body. All such complications of course tend to aggravate the ulterior disabilities which the wounds of the special organs under consideration entail.

Although wounds of the genito-urinary organs are only seriously dangerous to life in exceptional cases, or when they are associated with some grave complications, many examples occur among men who have been invalided on account of wounds of this nature, in whom, although life has been preserved, it has been made permanently miserable and almost intolerable by their consequences. In some instances invalids are almost debarred from social intercourse in consequence of the offensive effects of urinary fistulous openings of a nature beyond surgical repair, and in other instances, especially when the organs of reproduction are concerned, the subjects of such wounds become the victims of uncontrollable depression and melancholy. In the minds of most invalids who have become the subjects of traumatic mutilations of these organs, there is a natural repugnance to their nature being made generally known, so that these men are deprived of much of the sympathy and consolation which others often derive from wounds of other parts of the body, when they have been received in action against an enemy and in the service of their country. The ulterior moral effects of these wounds should therefore be taken into account, as well as their physical results, when estimating their consequences on the men on whom they have been inflicted.

Solitary shot wounds or shell lacerations of the scrotum are not, as a general rule, followed by any persistent ill results; although they may be extensive, they are usually completely repaired under ordinary treatment. But when, as generally happens, they are accompanied by injury of one or both testes, this complication frequently leads to permanent disability and trouble, the amount of which depends on the degree of the injury. Contusion of a testis will occasionally lead to inflammation, abscess, and its consequences, or may gradually occasion its atrophy. Perforation of the organ will also in some instances be followed by atrophy; and occasionally the remaining testis, although apparently not directly injured by the shot, will also eventually become atrophied. In some instances neuralgia of the testis, and pain along the spermatic cord, and tenderness on pressure, have endured for years. Extirpation of one or both testes has occasionally to be resorted to on account of the severe degree of laceration or crushing to which the organs have been subjected. In cases of double removal, although there may not be eventually incompetency for physical labour, the permanent loss of organic

function may be a serious calamity as regards the individual, and gives a just claim for pension or compensation in military service.

Wounds of the penis may be either grooving, perforating, or lacerating wounds, and may be limited to the integuments and corpora cavernosa. They are, however, often accompanied by corresponding wounds of the urethra. Ablation of the penis by a projectile, whether complete or partial, necessarily includes injury of the same nature to the urethra. When thus complicated, the wounds in a large number of instances lead to ulterior consequences of a very disabling and often distressing nature. In some instances the urethral lesions are followed by permanent stricture which is incurable, owing to the special conditions of its traumatic origin, so that the invalid continues to suffer for the rest of his life from incontinence of urine, or from difficulty of micturition, which may eventually give rise to vesical and renal disorders. Such patients are generally subjected to the compulsory use of instruments for relief of the bladder. In other instances a shot wound of the penis and urethra is followed by a urinary fistula, which under various conditions may defy operative proceedings for its cure, and become permanent. Many shot wounds of the penis attended by loss of substance are followed by contraction and distortion, so that interference with its function and pain are caused when it is in a state of excitement. Complete removal of the penis, and with it more or less of the scrotum and its contents, has now and then occurred, from grape-shot or from a large fragment of a hollow projectile. The permanent results of these extensive lesions must always be of a very sad description, and general health is often impaired by them. They are the more serious, because the soldiers who suffer from them in war time are usually young men, or men in the prime of life and activity. They have in occasional cases induced a suicidal tendency.

Wounds of the external generative organs are sometimes complicated with lacerations of the perineum, with lesions of the anal orifice, lower end of the rectum, of the prostate and other adjoining parts, or with more or less extensive wounds of the soft structures on the inner aspect of one or other thigh, or of both thighs. In certain instances they have been associated with fracture of a bone of the pelvis or of the femur. In such complicated cases the disabilities which usually result from these accompanying injuries have to be added to the ulterior disabling effects of the lesions of the genito-urinary organs, when the men who are the subjects of them survive to be invalided and are discharged from further service on pension.

Disabling results of gunshot injuries of the extremities.—Wounds of the extremities, although they may be limited to the soft parts, often entail consequences which seriously interfere

with the proper performance of the functions of the injured limbs. The interference occurs, however, in very variable degrees. In some instances it is hardly noticeable, in others it is such that total removal of the limb is regarded as preferable. The permanent effects already described of wounds and injuries affecting the cutaneous, muscular, and tendinous structures in other parts of the body, are applicable to the same structures in the extremities; but special considerations arise according to the extremity, whether upper or lower, in which the lesion has occurred, to the part of the limb wounded, the direction followed by the projectile, and the depth to which it has penetrated. As regards the hand, wrist, and lower part of the forearm, the amount of permanent disablement will be chiefly determined by the accident of the sheaths of the tendons having been opened, and the tendons torn asunder, or of their having escaped from the impact of the shot. A bullet travelling obliquely and dividing the flexor tendons at the wrist in its track, if all endeavours to secure union by treatment fail, will lead to deformities and loss of usefulness of the whole hand, or, if the division be limited to some particular tendons, will destroy the functional utility of the parts of the hand with which they are connected. Extensive loss of muscular substance at the upper part of the forearm from the stroke of a projectile of large size, as a shot from shrapnel or a heavy fragment of shell, may permanently deprive the subject of the injury of the power of supination and pronation, as well as of the use of his hand. It has frequently happened after wounds of the kinds described in which conservative treatment has been adopted, perhaps injudiciously, the parts preserved have been found to be such sources of pain and trouble owing to the rigidity and deformity which have ensued, that removal of them by amputation has been earnestly sought for, and, as records sufficiently prove, has been frequently practised. A stiffened finger or hand that has lost its prehensile power is not merely useless, but is an encumbrance, for it is exposed to repeated injuries from blows and accidental collisions, is in the way of other fingers, and so becomes a continual cause of anxiety and suffering. If amputation be resorted to, the disabling results will be greatly modified by the extent to which it has to be carried; if the thumb, with its mobility intact, have been preserved, and especially if one or more fingers have also been saved as opponents, the incapacity is very materially less than it is when ablation of the whole hand has been undergone. Shot wounds of the soft parts in which division of one of the nerves—the ulnar, median, or radial—or of more than one has occurred, are followed by loss of function of the parts supplied by them, by atrophy of the paralysed muscles, and by various deviations of the hand and fingers, according to the particular nerves divided. Corresponding results are met

with when the flesh wounds occur in the lower extremities, but they are manifested by more or less loss of the movements concerned in progression. Extensive lacerations of the muscles of the calf of the leg by shell fragments occur not unfrequently, and cause deviations of the foot, impaired power of movement, adherent cicatrices with tendency to ulceration and pain. If such wounds occur in the thigh, or involve the hamstring tendons, the function of the knee-joint becomes impaired, the whole limb weakened, and freedom of movement more greatly impeded. If the wounds be accompanied by nerve lesions, paralysis results, more or less complete according to the amount of damage done to the nerves implicated, and the disability and claim for pension among military invalids become proportionally increased, for their condition not only unfits them for military duties, but in all cases impairs, and in many totally destroys, their power of earning a livelihood by practising the trades or doing the work to which they had been habituated before enlistment.

Still more general are such disabilities when the wounds have been accompanied by fracture of a bone or bones, and either from the nature of the fracture itself, from casual occurrences during the course of treatment, or from the irregular manner in which consolidation has taken place, the injury has led, as so often happens after gunshot fractures, to shortening and distortion, to loss of power of sustaining weight, stiffness of neighbouring joints, adhesion of tegumentary cicatrices at the seat of fracture, or to atrophic changes and loss of movement in the limb to which the damaged bone or bones belong; or in which the attendant lesions have been of such a nature as to have caused amputation to be necessary. In the upper extremity, when the humerus has been subjected to a shot fracture, and the bone has not been much comminuted, and no important complication has occurred, the patient after consolidation may in more or less time recover sufficient strength and freedom in the injured arm to be able to return to duty in the ranks; but in a majority of even relatively slight cases there remains a loss of functional power sufficient to incapacitate a soldier for an efficient use of his rifle, although he may be but little disabled for occupation in civil employment. When the fracture has happened to take place in the forearm, whether it be limited to either the radius or ulna, or extends to both bones, the wound is very frequently followed by impaired or total loss of power of pronating, supinating, and rotating the hand and forearm. Lateral deformity of the hand has often followed a shot fracture of the radius. Pseudarthrosis has not uncommonly resulted from shot fractures both in the upper and lower divisions of the upper extremity. Stiffness of neighbouring joints, the effect either of disuse, or of inflammatory conditions which have arisen during the treatment, is also a frequent sequence of such wounds.

In the lower extremity, if the fracture has been in the femur, and conservative treatment has succeeded in saving the limb, the final result is not, as a general rule, very satisfactory. In many instances there is considerable loss of bone substance, or lateral displacement, or overlapping of the disjoined ends of the bone at the seat of fracture, and when these events occur, shortening of the limb and lameness are inevitable consequences. These conditions, moreover, are very often accompanied by an excess of new bone, much deformity of the wounded thigh, axial deviation of the extremity with inversion or eversion of the foot, wasting of the muscles of the thigh, and more or less anchylosis of the knee-joint. In rifle-shot fractures of the leg, which are usually very numerous in warfare, whether the fracture has occurred singly in the tibia or fibula, or whether both bones have suffered together, the usually slow progress of the repair often leads to permanent weakness of the affected limb. A tendency to varix is developed, partial anchylosis of the knee-joint and tibio-tarsal articulation takes place, and the leg and foot become swollen and œdematous after prolonged exertion in walking. In grave shot wounds of the foot with fracture, it has rarely happened hitherto that normal strength and springiness have been ultimately regained ; on the contrary, the remote issues of such wounds, even when caused by relatively small pistol bullets, have generally been more or less loss of natural form with a certain amount of anchylosis of the tarsal and other joints of the foot, in many instances persistent fistulous openings, and in the end not unfrequently partial or complete amputation of the affected parts. Whether these disabling results will be prevented, and normal functional use of the foot be regained, under more strict antiseptic treatment than has hitherto been practicable in field surgery, remains to be seen. In occasional instances, in addition to the permanent results above mentioned of gunshot fractures, military invalids are liable to suffer from various accidental complications. Such are ulceration of the cicatricial tissues adherent to the bone at the site of fracture, pain in the injured limb, sometimes persistent, sometimes occurring at intervals, and seemingly induced by particular states of weather or conditions of health ; and contractions from nerve affections. Occasionally after a gunshot fracture of a bone in one lower extremity, painful affections of the opposite limb are induced from inordinate or ill-balanced exertion to which it is subjected. The special difficulties in the way of preventing shortening after gunshot fractures of the femur when reunion is obtained, often causes this source of lameness to be very considerable, and, despite the artificial appliances employed to correct the deficiency in length of such injured bones, materially diminishes the after-usefulness of the wounded limb, although it has been successfully preserved. These difficulties are increased

when in addition to the shortening there is overlapping, much swelling, and loss of rectilinearity of the bone.

Anchylosis, partial or complete, may be a final result of a severe contusion, or of a penetrating wound, by a projectile, with or without fracture of bone, of any of the joints of either the upper or lower extremities, when such injuries have been treated on the expectant method, or when operative interference has been limited to the removal of detached splinters. Partial anchylosis causes impairment of function of a joint, the disability varying in degree according to the amount of adhesion or fixation between the joint-surfaces, and generally entails a liability to accessions of inflammation and pain from relatively slight injuries. Complete anchylosis causes entire loss of function of the anchylosed joint, though in some instances its function is partially replaced by substituted or increased action of neighbouring parts. It is usually associated with wasting, not only of the structures which were previously concerned in the lost articular movements, but also with more or less deteriorated muscular power and weakness of the whole limb. The amount of infirmity, and disability for labour, depending on these results varies, however, in different instances according to the size and situation of the joint injured.

In uncomplicated wounds of the shoulder-joint which have been followed by partial anchylosis, their mobility may in rare cases be completely restored after a long interval; but when direct collision of the shot with the surface of the head of the humerus has occurred, and more especially in cases in which splintering has been produced, or lesions of the scapula, or acromial end of the clavicle, have been added, the anchylosis is usually lifelong, and is often a source of much restraint and suffering. In such instances the amount of disability, although the anchylosis may not be complete, is often much greater than when resection has been performed; for even moderate exertion, no less than a direct blow on the affected joint, is apt to produce pain, and the hand and fingers, although their functions may be retained, can seldom be used as freely as they can be after resection of the shoulder-joint. Complete osseous anchylosis, though causing atrophy of the muscles directly concerned with the movements of the affected joint, when the use of the elbow, wrist, and finger joints is preserved, may interfere less with a serviceable use of the limb than when the shoulder is only partially anchylosed. The anchylosis of the elbow-joint much depends on the direction in which the joint has become fixed. If fixed in extension, the arm is practically impotent. If fixed at a suitable angle, however, and the mobility of the shoulder, wrist, and fingers has been preserved, and especially if, in addition, rotation of the radius has not been lost, the disability by no means prevents useful employment of the limb. When anchylosis of the hip, knee, or ankle joints has happened, the extent of the resulting

infirmity will also greatly be determined by the direction assumed by the articulatory surfaces. If the hip should have become fixed in a flexed position, or is so anchylosed that the extremity is diverted from the direction natural to it in progression, the use of the whole limb will be seriously impaired. Again, if the knee-joint be rigidly flexed, the function of the whole extremity will be proportionably impeded; and a similar disabling result may occur if the ankle-joint is so anchylosed that the anchylosis causes the foot to deviate permanently from its normal relations in direction with the leg. If, on the other hand, the anchylosis has so taken place that a serviceable direction of the affected joint has been secured, and there be no concomitant nerve lesion or other complication, the exercise of the principal function of the limb, that of sustaining the weight of the body and joining with its fellow-limb in progression, may not be so seriously or greatly obstructed.

When resection of an injured joint has been performed, the nature of the ultimate results of the operation, and consequently the amount of disability, will be influenced by the mischief done by the projectile to adjoining anatomical structures, especially to neighbouring nerves, the skill with which the operation has been performed, the kind of after-treatment adopted, and circumstances affecting the constitutional state of health of the patient while the treatment has been in progress. In successful cases of resection, with judicious after-treatment, there is not unfrequently a continued gain in strength, mobility, and usefulness of the mutilated member for many years after the healing process has been complete. In other instances, on the contrary, either from atrophic changes, from neglect or disuse, or from repeated accessions of local inflammatory action induced by injuries rendered almost unavoidable by the diminished power and activity of the member itself, the amount of usefulness which was obtained at an early period after the operation wounds had healed becomes lessened, or even entirely lost. In such cases it occasionally happens that amputation is at last resorted to as a less evil than that of the existing condition.

The ultimate use of the upper extremity, when one of its joints has had to be subjected to resection in consequence of a gunshot wound, depends greatly on the extent to which subsequent attention has been bestowed or an intelligent development of the available muscular power left in it. I have been led by observation of cases to believe that in a considerable proportion of those instances in which arms after such operations have been described as dangling, and little better than useless encumbrances, their condition has been due to neglect of the necessary after-treatment. The final issues of resection, as displayed in the histories of the comparatively recent great wars in the United States, and between France and Germany, have not been so favourable as it may be hoped they will be in the future. But in

many of the recorded failures it may be fairly deduced from their histories that the ill results were not due to the nature of the operations, nor to any fault of the operating surgeons, but solely to subsequent neglect of the patients themselves. The same fact was brought forcibly to notice in the well-known correspondence between Professor Hannover of Copenhagen and the German army surgeons respecting the final results of the resections which had been performed by them on the Danish soldiers during the war of 1864. It is marvellous what useful power may be obtained in apparently almost hopeless cases after uncomplicated resections of the shoulder and elbow joints, provided gymnastic exercises are judiciously and systematically practised for a sufficient length of time; just as, on the other hand, it is very noteworthy how speedily muscular structures waste and deteriorate after these operations when no efforts are made, or only ill-regulated efforts, to maintain their motility and restore their efficiency.

I have elsewhere shown what a remarkably large amount of power may be obtained in an arm with long ligamentous union between the separated bones after resection of the shoulder-joint.[12] A favourable issue after resection of the elbow-joint, so far as regards recovery of function and power, appears to be less hopeful than that of the shoulder; but the history of the following case, which I publish with permission of the subject of the injury, shows how useful an amount of power may be regained in an extremely unpromising case by the steady application of suitable exercises.

Major-General F. L., commanding a district in Bengal, when a major in the 2nd Punjaub Cavalry, in February 1878, consulted me respecting the condition of his left arm. He had been wounded by a rifle bullet in the elbow about four months previously at the battle of Shahjehanpore. The joint was much shattered, and resection of it was performed by Surgeon-Major Farrell, I.M.S. Some splinters were carried away by the shot, but the chief portions which were removed at the time of the resection were presented by the patient to the Museum at Netley, and are still preserved there.[13] These fragments include the trochlea and greater part of the condyles of the humerus, the outer half of the head and neck with a little over an inch of the shaft of the radius, and a portion of the ulna measuring from the end of the olecranon 4⅝ inches. The inner half of the head, the bicipital tuberosity, and part of the shaft of the radius, together with half of the coronoid process and part of the shaft of the ulna, had been shot away, About six weeks after the resection, passive motion of the parts concerned in the operation was commenced, but was shortly afterwards discontinued, no movement of the arm being allowed during the voyage from India to England.

On examination of the arm on the occasion of Major L.'s first visit to me, I found it to be practically devoid of all muscular

power. Ability to pronate and supinate the hand was entirely lost. The finger and wrist joints were extremely rigid. The index and middle fingers could be passively bent, but with pain, about half-way toward the palm of the hand; the ring and little fingers could not be moved at all. No attempts at flexion of the wrist could be borne. The patient complained of general numbness and aching of the arm below the elbow, but sensation was found to be everywhere present on pressure. The resection wound was nearly healed; only a small sinus leading to a limited spot of rough bone remained open. When the arm was by Major L.'s side the gap between the ends of the humerus and ulna measured about four inches; the forearm swung from the upper arm like a flail. An eminent surgeon in London whom Major L. consulted had stated that no ground existed for expecting restoration of muscular function, and had recommended a rigid case to be fitted and applied to the arm for its external support and protection. Major L. had had this support made, and was wearing it when I first saw him.

My experience led me to suggest a different course of treatment. It was obvious that under the plan of fixation and complete rest no improvement could take place, while it was likely that further structural deterioration would occur. I recommended that the arm-case should be worn loose merely as an arm sling by day, and left off at night; that warm arm-baths should be used night and morning for twenty minutes on each occasion, passive movement of the fingers, wrist, and elbow being practised as far as could be effected without causing pain while the arm was in the bath; and that the arm should be at once subjected to regular pulley and weight exercise, the weight to be increased in proportion as the arm became competent for the increased traction.

Major L. carried out the treatment very thoroughly, and after a month reported to me by letter that shortly after he had used the baths and exercises the sensations of numbness and general uneasiness which had previously troubled him disappeared, that he could now flex the first and second fingers down to the palm of his hand and press it with some force, and that he had gained much power in the other two, as well as in the wrist, which he could use with some effect in driving. He could flex his arm when hanging by his side to an angle of about 20°. He had increased the weight he used with the pulley from one to three pounds, and could now work the arm without the aid of his right hand.

In the course of the following month an abscess, followed by the escape of a small sequestrum, interrupted the exercises for about a fortnight. At the end of that time the opening was healed, when the exercises were resumed. I saw Major L. in July, about four months after the commencement of the treat-

ment. Nearly all the normal movements of the hand and wrist had then been regained, and very considerable power recovered in the arm. It was arranged that the baths and exercises should be regularly continued.

In October 1878 Major L. left England to rejoin his regiment in India. He now wore a jointed arm support which he could bend or extend at pleasure. By a simple contrivance designed by himself, he could also fix it at a given angle so as to prevent sudden strains when riding. In August 1879 Major L. wrote to me from Kandahar: "My arm has wonderfuly improved. A sort of false joint has formed, so that when the arm is flexed the end of one bone passes into a groove in front of the end of the other. This has much increased the power. I am now able to manage a quiet horse with my left arm.

Colonel L. returned to England on short leave of absence in July 1881, and I again saw him. He had gone through the Afghan campaign, doing regular duty with his regiment all the time. The arm was still shapeless and dangling when hanging inertly by his side, but capable of great power when put into action. He could raise it without help, and touch the top of his head with his hand. On examining the damaged elbow, I found the condylar end of the humerus enlarged, with a scaphoid-like depression formed in the sawn surface where the trochlea had been, while the end of the radius had made a hollow bed for itself on the outer side. On Colonel L. using the arm, the forearm was pulled up to the end of the humerus, and the top of the ulna, which had become convex on the surface, was brought against the cup-like cavity in the end of the humerus. A fulcrum was thus obtained on which the forearm exerted itself. Pronation and supination were complete when the forearm was leaning on a table; without this support the movements could only be partially effected. The movements of the wrist joint and thumb were quite perfect, and of the fingers nearly so. Full use of the shoulder was preserved. Although the brachial muscles acted strongly in drawing up the forearm to the upper arm, they were not much developed, and the biceps was especially small. Colonel L. had carried on the gymnastic exercises for about a year in Afghanistan, but had discontinued them for some months before this visit. I strongly advised their continuance.

Colonel L. visited England again in the year 1888, but I had no opportunity of personally observing the changes that had occurred in the arm since I saw it in 1881. As Colonel L. was residing near Clifton, I asked my former colleague Dr. Fyffe to examine it for me. He reported: "I tried his powers of lifting. He took my arm-chair in his hand, and raised it straight from the floor without bending the elbow. I put my gun into his hands, and he went through the ordinary motions and attitudes of a sportsman with

perfect ease. I then put a 14-lb. dumb-bell into his left hand. He first lifted it easily in the straight position from the ground. He then took it up, held it for a moment at right angles to his body, and raised it above his head. I measured the difference in length of the two arms, and found the left fully four inches shorter than the right. The power and functions of the hand and fingers appear to be perfect." Dr. Fyffe concluded: "I should be sorry to get a straight blow from Colonel L.'s arm now." Colonel L. left for India again in March 1889, and still remains on duty there.

During the time I was putting together the foregoing notes, a pensioner who had undergone resection of the elbow applied to me to sign his pension certificate. His condition affords an instructive contrast with that of General L., and well illustrates the results of neglect of exercise. It is an analogue of many other similar cases that have come under my notice. The resection in this instance was skilfully performed at Netley in 1877 by the late Surgeon-Major Porter, and the parts were left in every respect favourable for the recovery of muscular power. The arm was now powerless, and when removed from the leathern case in which he carried it, either hung down helpless by the man's side, or had to be supported by the hand of the other arm. The brachial muscles were extremely wasted, and no power of pronation or supination of the hand remained. With the arm resting on the table, or when the artificial support was worn, he could barely use his fingers for signing his name, and could only just move his wrist backwards and forwards. He had not, as I learned from him, made use of any set exercises of the joint or arm since his discharge from Netley. In this instance all the elements of a most serviceable limb were present, but they had not been developed, and the arm was thus rendered almost useless.

The survivors among men who have undergone excision of the hip-joint for gunshot injuries inflicted in war have been few in number, and the majority among them have recovered with limbs shortened, more or less impotent, and depending on the assistance of crutches for support in walking. In a few exceptional cases the resected joint has become efficient, even in one instance to the extent of enabling the subject of the operation to perform all the natural movements of the hip and to do heavy work as a labourer, and in a few others enabling them to walk considerable distances with only the aid of a stick. With improved means of transport from the scene of conflict, better hospitalisation, and more thorough antisepsis, we may expect the proportionate numbers of recoveries in uncomplicated gunshot wounds of this joint to be greater; but grave impediments to useful power of sustentation and progression must always be anticipated as the probable result of the operation of hip-joint resection. When regarding the imperfection of such results, however, the disabilities consequent on them should of

course be considered side by side with the serious risks of loss of life itself in corresponding gunshot wounds of this important joint, under the alternatives of expectant treatment or amputation.

Resection of the knee-joint is a proceeding which has rarely been successful, or even resorted to, in field practice. It is indeed hardly applicable under the usual conditions of warfare. Occasionally circumstances may render the operation after a gunshot wound both justifiable and hopeful in European warfare, particularly when there is no necessity to subject the wounded man to prolonged transport from the place where the injury has been received; and when firm anchylosis in the extended position is obtained, the incapacity for progression and labour may be reduced to a very small amount, notwithstanding the loss of mobility in the joint. In one case quoted by Professor Gurlt, a useful limb resulted, with the retention of a certain amount of mobility. It is hardly probable, however, that resection of the knee will be resorted to more frequently in wars of the future than it has been in the past, as all indications point to the hopefulness of more successful results being obtained from conservative practice in wounds of this joint than from resection.

As regards primary resection of the ankle-joint for gunshot wounds, very few survivors have been brought to the notice of invaliding surgeons; but the number has been larger when it has been performed as a secondary operation. As a general rule, the pensioners concerned have remained more or less disabled, unsteady in walking, and subject to aching and pain on trying to walk beyond a moderate distance. The feet have become in various instances deviated in direction, causing much lameness and suffering, and entailing the necessity of artificial assistance from a staff, or even in some instances from crutches. In a very few exceptional cases, in which not only firm bony union has been obtained, but scarcely any shortening of the limb has eventually occurred, the men have been able to follow employments requiring active movement, without any artificial aid or marked inconvenience. The functional results of resection of the ankle-joint when performed as a secondary operation may possibly be generally better in the future than they have hitherto been; but in this, as in gunshot wounds of other joints, resection, it may be anticipated, will less frequently be required, owing to the more frequent adoption and more successful results of conservative measures.

After exarticulation of a limb, or amputation of part of a limb, it is almost needless to observe that a soldier is rendered useless for all active professional duties. Exarticulation and amputation also impair his future usefulness in civil life, according to the member removed, and the nature of the trade or occupation to which the man had been brought up, and by means of which, if he were in a sound state, he could still obtain a living. Stumps

left by amputation are often subject to tenderness on pressure, pain, ulceration of cicatrices, abscess, exfoliation of bone from moderate injury, and other accidents throughout life.

Extremely sad, as a general rule, is the condition to which patients are permanently reduced after double amputations, which, as heretofore mentioned, are by no means very unfrequent results of war injuries, especially of explosions and shell wounds. Double amputations leave men the more helpless the nearer they have had to be performed to the trunk, and especially is this the case when the limbs removed are the two upper extremities. When the amputations have been in the two lower extremities, artificial substitutes to assist in bearing the weight of the body and in progression can be generally arranged with fairly serviceable results. Men can better adapt themselves to their doubly maimed condition when one amputation has been in the upper and the other in the lower extremity; but even in such cases the power of self-help and capacity for useful employment will greatly depend on special circumstances—whether the operations have been performed on the same side of the body or on opposite sides, the distance from the trunk of the amputations, and personal qualities of the individuals concerned. Life has been preserved after treble amputations for gunshot injuries; and the fact has been recorded of recovery having taken place after both upper and lower extremities being amputated. After such a quadruple mutilation, the truncated patient must be reduced to so hopeless a state of infirmity and helplessness as to make it questionable whether the preservation of life itself is indeed desirable under such circumstances.

SECTION VIII

GENERAL TREATMENT OF GUNSHOT INJURIES IN FIELD PRACTICE

CHAPTER I

FIRST HELP TO MEN WOUNDED IN BATTLE

Nature of help required.—The circumstances of battle vary so greatly in the nature, physical features, and extent of the ground over which they are fought; in the number, tactical disposal, and movements of the troops engaged; in the duration of the fighting, especially as to whether some hours of daylight remain or it has only stopped when darkness has set in; in its result, such as complete or partial victory; in the opportunities for previous preparations, and in many such matters, that although rules may be laid down as to the time when the first professional assistance shall be given to men wounded in action, as well as to the manner in which this aid shall be afforded, these rules can never be carried out with punctual exactness. But it is an established principle in all regular armies, that, as soon as circumstances admit of it, the wounded are to be removed, or, if able, are to retire from the ground where the action is being fought, are to have their wounds professionally examined with the least practicable delay, and to receive, if necessary, a certain amount of professional surgical treatment preliminary to their being transported to the field hospitals, which, in European warfare at least, will almost invariably be established at a very considerable distance in rear of the field of battle itself, owing to the great range of modern projectiles. The moral effect of such an arrangement among troops is probably no less important than the beneficial effect from a surgical point of view. In many instances in which the injuries presented are found to be simple flesh wounds, without bleeding or any important complication, no application to the wounded parts beyond a simple covering will be necessary, nor any special surgical attention be required; such patients can proceed unassisted, without delay, or after a very short rest, to the place where the nearest

field hospital is established. Even in these cases, however, a word of assurance from the surgeon will often be a source of much comfort to a wounded man. In some instances the wounds presented will be of such extreme gravity, it will be at once obvious that the patients are beyond surgical help, and must speedily succumb to the injuries to which they have been subjected; in other cases of a more hopeful character some surgical operations may be urgently necessary to ensure the safety of the patients; hæmorrhage to be arrested; parts extensively lacerated to be replaced and secured; a portion of a limb left hanging by a few tissues to be completely detached; and fractured bones with protrusion to be adjusted and receive support. In others, again, some technical provisional dressings will require to be applied; and, not unfrequently, some special directions to the bearers of the wounded men will be necessary, some instructions with a view to prevent the occurrence of further hæmorrhage, to avert aggravation of the original injury from malposition, or to obviate harm that would be caused by undue movement in the course of the conveyance from the vicinity of the battle-field to a field hospital.

While a battle is in progress, such preliminary measures of treatment are performed by surgeons who are placed in the most convenient positions available for that purpose. These positions are generally selected on certain definite principles, which will be explained hereafter in the chapters on organisation and administration of medical service in the field. Some primary help may occasionally be given immediately in rear of the place of fighting, but the principal provisional assistance will be afforded at the 'dressing-stations'—stations which ought to be sufficiently near and accessible to admit of help being afforded as early as possible to the wounded who are brought by the regimental or company bearers to the surgeons, and at the same time sufficiently far from the field of action and screened from exposure as to protect both surgeons and patients from all avoidable risk of injury from shot. The duties, indeed, performed in the immediate rear of the troops engaged usually resolve themselves into a disposal of the wounded according to their condition: sending away the men urgently needing attention on stretchers toward the dressing-stations, keeping back some that must speedily succumb to hopelessly fatal injuries, returning men with very slight wounds to their respective corps, and only in very exceptional instances undertaking any sort of operative interference.

Preliminary examination of wounds.—Whatever the arrangements for attending to the first necessities of wounded men may be, the preliminary examination of their wounds at the advanced positions of help, whether in proximity to the fighting line or at the dressing-stations, should be only cursory and general;

the special diagnosis in doubtful cases must be established further in rear, where there will be more appliances and more time at the disposal of surgeons for the work. A technical and thorough exploration of a gunshot wound in the front while an engagement is progressing is out of the question; it could not be accomplished, and the attempt to carry it out would probably lead to septic complications and be productive of much mischief. But though the examination is to be one only for general observation, it must be conducted on fixed principles, and with a definite object in each instance. It should not be made roughly or carelessly, though, in consideration for other patients, it must be made very quickly. If the position or direction of a gunshot wound is not obviously apparent, its situation must be sought for without loss of time, but yet with due caution. More clothing should never be removed in any case than is absolutely necessary to lay bare the wound, especially on the field itself, nor under ordinary circumstances after arrival at a field hospital. In campaigning it will not often happen that a wounded soldier is able readily to replace articles that are cast away or are much torn; and if the weather be bad or the season be cold, as some time may elapse before the patient can obtain blankets or other articles necessary for protection and preserving a proper amount of warmth, he may suffer from the exposure. At the advanced lines of help, no clothes at all should be removed; they should only be opened, whether for the purpose of exposing the wound to view or removing constriction. If a bone be fractured, the temporary supports should be placed outside the uniform, unless some special cause, as hæmorrhage, enforces the need for uncovering the seat of injury. The removal of the uniform should be deferred until after the wounded man has reached the field hospital, whenever practicable. The removal of clothes on or near to the field of action itself can only be done with difficulty; it delays the removal of the patient to the place where the necessities of his case can be best attended to; and it takes up the time of surgeons and attendants, and proportionably prevents attention to some others of the numerous calls which will be certainly made upon them at such a time. Whenever there are imperative reasons for immediate exposure of a wound, instead of removing the uniform covering the wounded part, if the wound be in one of the extremities, the stitching of the seams of the sleeve or trouser and of any under-garment should be speedily divided by the knife or scissors of a hospital bearer or attendant to an extent sufficient for the complete exposure required. If the wound be in the foot, the backs of the boot and the sock should be cut open: on no account should attempts be made to remove the boots by pulling them off. The general principle in the field should be to open all coverings, when circumstances require it to be done, to expose the injury

or wound sufficiently for ascertaining its nature, and for applying a primary dressing, but at the same time to leave the coverings in such a state that they may still be made use of until fresh clothing can be obtained. In field surgical practice such matters are by no means trifling, for they often have an important influence on the patient's comfort and subsequent welfare.

Objects of the preliminary examination.—One of the principal objects of the preliminary examination of a shot wound is to determine whether hæmorrhage is going on, or is likely to occur during the further removal of the patient, so that it may be at once stopped in the former case, and steps be taken to prevent its occurrence in the latter. The next object, should there be no hæmorrhage demanding attention, is rapidly to ascertain whether any and what provisional treatment will improve the general state of the patient, diminish the dangers and discomforts of his wound, according to its particular features, and more especially to apply such dressings or supports as will best protect the wound from septic influences, and at the same time obviate the risk of additional injury during his transport further to the rear, or during the interval which may elapse before he will again come under surgical observation and care.

The provisional treatment of wounded men.—All provisional treatment, when there is no active bleeding to demand the surgeon's interference, should be of the simplest kind, and such as can be carried out with great celerity. Elaborate appliances, dressings that require a considerable time for arranging them, are quite out of place. As a general rule, there are too many wounded and too few surgeons, the risks from sudden movements of troops and the enemy's missiles are too great, and the means altogether insufficient, for such attention to be given to individual cases. The principle must always be kept in mind that it is the duty of surgeons in the front, whether near to the fighting line or at the dressing-stations, to pass on, as quickly as possible, every wounded man that can be sent to the field hospitals in the rear with safety and propriety. Cases in which the wounds are found to be so trifling that the subjects of them can be retained for helping in attendance upon their more severely wounded comrades, or sent back to rejoin their corps, and others of a nature so manifestly fatal that the patients cannot long survive, and again a third class of men among whom there is imminent risk of loss of life unless some professional operation be immediately resorted to, are the only exceptions to this rule. The cases last named, in which there is an extremely urgent need for some surgical proceeding as a means of saving life, should not be sent away in transport vehicles to the field hospitals; but to such, even at the field dressing-stations, surgeons should devote all possible attention. Even this precept, however, must be followed with a certain reserve, for no

surgical operation that will require much time in its performance should be undertaken; the movements of troops engaged in action are so uncertain, that the surgeon may not be able to complete it, and the patient may be left in a worse state than if the operation had not been begun. With the exception, then, of the most indispensable surgical operations, and such as can be surely and speedily accomplished, whatever the surgeons at the most advanced lines of help may be able to do in the way of surgical assistance should be done 'off-hand,' and should be directed principally to the prevention of additional injury during the passage to the field hospitals, where complete and accurate examination of the nature and probable complications of a wound can alone be made, and where the patients can remain at rest, for some time at least, after having been subjected to the required treatment. Clearing away by the hand or a pledget of carbolised tow any clot that may interfere with a general view of the wound; the cleansing of the wound opening and its vicinity by some antiseptic lotion kept near at hand; the removal of any missiles or foreign bodies which may be plainly obvious to sight or touch, especially such as are in situations involving hazard to the patient—a jagged and sharp-edged fragment of shell lying near an artery, or other important structures, for example; the application of some folds of antiseptic gauze or pad of carbolised tow to the wound, secured for the moment in whatever may be the most ready way, by a short strip of linen and pins, by the triangular bandage, the use of an ordinary handkerchief, by anything, in short, that will keep the covering in its place and prevent undue movement of the parts concerned in the injury; temporary arrangement of any available support, whatever may be at hand, for a broken limb; protection of the wound against dust, cold, or other objectionable circumstances likely to present themselves in the transit, if these matters have not been already attended to, or only imperfectly carried into execution by the bearers; if shock exist, and it be not a case where its prolongation may be of service, as in likelihood of bleeding, the administration of a little alcoholic stimulant, wine, rum, brandy in water, or, in their absence, some aromatic ammonia, or some similar restorative, for its relief; if there be debility and exhaustion from loss of blood, fasting, cold, or other causes, and circumstances have allowed it to be got ready (a rare contingency, however, while an action is in progress, excepting under very special circumstances or when the wounded are in villages or towns), the supply of a little nutriment in the shape of meat essence; these acts of primary attention require little time for their execution, and will prove sources of comfort, perhaps of great service, to a patient.

If the primary antiseptic dressing applied to a wound is moistened with some antiseptic lotion, and can be maintained moist until the patient reaches a field hospital, it will be less

irritating to the part, and less troublesome and painful to remove, than if it be applied dry. Several hours may elapse before the wounded man can reach the field hospital, and the dry covering by that time will probably have become firmly fastened by hardened clot to the edges of the wound and surrounding skin. When neither sufficient lotion nor clean water can be obtained, as often happens in the field, a small fold of a cotton or linen bandage steeped in carbolised oil and placed over the dressing forms a convenient temporary substitute. The piece of lint contained in the 'first field-dressing' supplied to each soldier on taking the field in the Ashanti expedition under Sir Garnet Wolseley, had ointment spread upon it, and was wrapped in waxed paper. This dressing was favourably reported upon; but as the dressings had to be kept in store prior to being issued for use, the ointment must have been liable to become rancid or otherwise deteriorated. Surgeon-Major Wyatt, in his report on the siege of Paris in 1870–71, mentioned that patients found a combination of glycerine and water on charpie the easiest of the applications employed for immediate use to wounds in the battle-fields round Paris, when the subsequent transport to the ambulances was long and tedious. The glycerine prevented the dressing from becoming stiff and harsh, and adherent to the wound and its neighbourhood. By sprinkling a little iodoform powder on and about the wound prior to the application of the glycerine dressing, it might be kept aseptic until the time when it could be definitely attended to in hospital.

Anything of the nature of voluminous bandaging of wounds should especially be avoided in the field. The covering will have to be removed when the patient arrives at hospital; so that, not only will the application of it be a waste of time which might be far more profitably spent, but the removal of it afterwards will be a source of needless additional trouble to attendants, and frequently of pain to the patient. The able and experienced Mr. Guthrie published some 'Directions to Army Surgeons on the Field of Battle' at the time of the outbreak of the Crimean war, and one of them was the following: 'Bandages or rollers applied on the field of battle are, in general, so many things wasted, as they become dirty and stiff, and are usually cut away and destroyed without having been really useful.' This was the result of his experience during the Peninsular campaigns.

The means of applying a temporary protection to every wound will not be wanting if the 'first field-dressing' has been issued to each soldier on taking the field, and is carried on his person, as it should be according to established regulations. But should this precautionary measure have been neglected, or the dressing not be forthcoming when required, and the wounded be numerous, occasions may occur when the surgical materials at the disposal

of the surgeons at the first lines of assistance will be expended, while many patients still remain unattended to. It is satisfactory to reflect that even under these circumstances (circumstances which have so often happened in war that they may well happen again) the most necessary help can still be given to those to whom surgical aid is really of essential importance. An impromptu tourniquet, or a compress of any material at hand secured by a handkerchief, can be applied to a bleeding vessel; supports can still be improvised from a variety of articles for a broken limb; and these will form the majority of the cases in which primary attention in the field is a matter of absolute necessity. The soldier with a simple wound will not suffer much even though no very early dressing or covering be applied to it. The patient who has fallen from shock or from faintness will generally recover where he lies if his uniform clothing be released, or he may be carried away on a stretcher without material harm resulting from his condition; in some particular instances even with more advantage than if he had been roused from it by the administration of some of the usual remedies. If adequate transport arrangements have been provided, and the service is well administered, no interval of time worth serious consideration as regards its influence on wounds of comparatively minor degrees of gravity will elapse before the necessary care and attention can be afforded to the patients at the field hospitals. In the meantime the surgeons at the advanced dressing-stations will be devoting their energies in favour of the more badly wounded who most require their attention.

Removal of wounded after an action is concluded.—Circumstances usually prevent many of the wounded from being attended to while an action is in progress, so that they remain to be cleared away from the place of conflict after the conclusion of the battle. Under such circumstances wheeled ambulance conveyances will frequently be able to be brought up near to the ground over which the wounded are scattered, or, if the action be decisive, may even be brought upon the ground itself. The serious duty of collecting and removing wounded men who have been left lying on fields of action should never be delegated to the attendants who accompany the ambulance conveyances, as often has been done; it ought, whenever possible, to be performed under the direct supervision of medical officers. Many questions arise on such occasions which demand settlement without any delay, and which can only be settled, with due regard to the interests of the wounded, by professional decision. If any of the men who are picked up are to be moved to the hospitals on mule seats or litters, the medical officer in charge should make such arrangements as will enable him to see that the most suitable cases are selected for such comparatively trying modes of conveyance, and that all

essentials as regards their protection are attended to before they quit the ground. If the removal is to be by wheeled vehicles, the wounded, as they are brought on the stretchers to the waggons, should receive similar observation and attention before they are lifted into their places in them. It is not to be forgotten that many of the wounded will have been lying long unattended to, and that they will be suffering proportionately from serious prostration, mental as well as physical.

The charge which devolves personally upon medical officers as regards this preliminary attention will vary greatly according to the amount of training, experience, and conduct of the bearers or hospital attendants acting under their directions. Well-trained and efficient bearers will leave little to be done on the spot by medical officers in all but exceptional cases; inefficient bearers will leave very much to be done by them—often, in the interest of the sufferers, causing them to have to undo what such bearers from their incompetency have done wrongly. The aptness of manner with which this important duty is directed and accomplished, notwithstanding the pressure for time which almost always exists on occasions of gathering and sending away wounded men from fields of action, not only forms a test of the knowledge and expertness of the field surgeon concerned, but is a matter of vital importance to patients. There is not the expenditure of time that is unavoidably caused when wounded men have to be carried long distances by hand before a regular transport vehicle can be reached, but there is frequently much delay nevertheless from other causes. It is a duty which often takes a long time to perform, owing to the fact that the wounds of men who have been unable to move from the places where they have fallen, or who have only been able to reach spots near at hand, are generally of a grave character, to the extent of ground over which the men are often scattered, and frequently also on account of their numbers. It is one, too, which has usually to be performed when the day is considerably advanced and darkness approaching, and not unfrequently when it has become dark, and only the light that can be obtained from lanterns is available. The hospitals to which the wounded are to be transported will not unfrequently in European warfare be in villages, towns, or camps, three or four miles, if not farther, to the rear; and from their distance, and also owing to the blocking up of the usual routes of communication by military vehicles of all kinds, not to mention other impediments to free locomotion at such a time, especially at night, many hours must in all probability elapse before the opportunity will again occur of affording to the wounded men professional care and assistance. If the surgeon in charge should know that the wounded can be directly and without loss of time conveyed to hospitals where surgical care and attendance, and all things proper for their

injuries will be certainly forthcoming, where too they will probably be free, for several days at least, from subsequent disturbance, he may trust to slight provisional treatment and send them away without any hesitation or delay; but if he is uncertain on these points, he should manifestly take special care to provide against possible contingencies, and do all that he consistently can for their wounds and injuries before he allows the patients to leave his supervision.

There is another source of need for the presence of surgeons on the ground whenever the duty of clearing fields of action is being performed. In occasional instances, in which the wounds are not of such a nature as to be manifestly destructive to life, doubts will arise whether the men lying helpless on the ground have really succumbed to the effects of their injuries and are dead, or whether they are only in a state of unconsciousness or powerlessness, from syncope, extreme shock, coma, or some other cause. Numerous instances have been recorded of men being left for dead on fields of battle, but who, from an accidental observation by a passing surgeon, or from a casual movement, or from some particular occurrence at the time of collection for burial, have been discovered to be still alive. This has especially happened in cases of injuries to the head, which for the time have deprived soldiers both of power of motion and of consciousness, as well as in cases of prolonged syncope from loss of blood. The questions to which such matters give rise can only be settled by professional examination, and the bearers or other persons around will naturally look for a surgeon to decide them.[1]

Assuaging thirst of wounded men.—I have elsewhere referred to the urgent thirst from which most men wounded in warfare suffer. Care is usually taken that soldiers, when preparing to go into action, have their water-bottles filled; but this supply is often exhausted before the action begins. The orderlies who carry the 'medical field companions' are also provided with a supply of drinking water; but the quantity that can be carried is unavoidably so limited compared with the demand, that its economical distribution, when there are not easy means at hand for replenishing the water-bottles, requires attention. Water is the natural beverage for relieving thirst, and under ordinary circumstances is the only one that should be used among wounded in the field. Spirituous stimulants, even when diluted considerably, do not quench thirst, and, as a general rule, when given merely with the object of doing so, increase excitement and are hurtful. In assuaging the thirst of wounded men, regard should be had to the circumstances of the time. In warm weather the coldest water from a spring, if it can be obtained, will be the most grateful and the most appropriate; in winter, cold drinks are in a great degree hurtful. Experience proved this latter fact, during the winter months of 1854–55, among the men wounded in the trenches before Sebastopol, and

the truth of it was again noticed in the winter portion of the Franco-German war of 1870–71. The depression of nervous energy, and of the temperature of the surface of the body, by exposure to cold; the aggravation of these depressed conditions when there has been loss of blood, excessive nervous excitement, or great fatigue, naturally indicate that whatever beverages are given should be in a state to add warmth to the frame, and, within due bounds, vigour to the circulation. Warm weak tea or coffee, warm broth, are really the only suitable beverages under such circumstances, but the means of supplying them can scarcely ever exist while fighting is in progress, and but rarely so on the ground from which the wounded are removed after the fighting is over; still, if circumstances ever admit of their being given, the opportunity should not be neglected. They are restoratives of vital importance. They become all the more essential when a wounded soldier has remained long without any attention, when he has been lying on wet ground, or exposed to rain or snow. Spirituous stimulants may often be given with benefit under these special circumstances, when other liquid restoratives are not at hand; but they should be administered cautiously, only in small quantity, and then adequately diluted with water. If it be possible to combine them with heated water, their effect will be all the more advantageous.

Attention in cases of hæmorrhage.—Under any circumstances, whenever a wound, with bleeding which shows no tendency to stop, is brought to the notice of a surgeon in the field, whether at the rear of the fighting line or at a dressing-station, the case should always receive his most active and careful attention. If the bleeding be proceeding from a small arterial branch, some pads of antiseptic cotton wool or tow, and moderate pressure by a bandage, particularly if the pressure can be exerted against a bone, will in most cases arrest it; if it be venous, it will be probably found that there is an impediment to the return of the blood through some of the adjoining veins owing to the pressure of tightly fitting parts of the man's uniform, when the release of these obstructions, with the application of an ordinary dressing and support, will be sufficient to arrest it. If, however, the hæmorrhage is occurring from injury to a vessel of considerable size, it must receive more deliberate treatment. At the fighting line itself, on the occurrence of a violent escape of arterial blood from a wound in a patient within reach of a surgeon or trained attendant, all that can be done to check the flow is to make pressure by the finger on the main trunk if the wound be in one of the limbs, or in the wound itself by a finger, until a tourniquet or substitute for one can be applied, preparatory to the man being carried to a dressing-station, and the necessary steps being taken there for a more definite arrest of the hæmorrhage. The surgeon

at the dressing-station should not trust to the continued employment of the tourniquet which has been employed as a first measure, nor to any such temporary makeshifts as compresses, styptics, or plugging, which will probably only irritate the wound, cause diffused infiltration, and conceal what is going on in it; but he should invariably, if possible, secure the wounded vessel at once by ligature. To send a patient away who is known to have had one of the larger-sized arteries opened, without this safeguard and depending on a tourniquet, even in broad daylight, but especially at night, would expose him, during his transport and while in the hands of, at the best, more or less imperfectly informed attendants, to the risk of the instrument becoming disarranged or loosened. The patient's life might consequently be endangered, either by gradual loss of blood or by sudden copious hæmorrhage. And, again, if the tourniquet retain its position, the circumstances of warfare are so changeable and uncertain, that many hours, if not a day or two, may elapse before the patient is seen by another surgeon. In the meantime some of the ill results of strangulation of the limb may have begun to appear. So many accidents have occurred from the causes just referred to, that every field surgeon should hold it to be a sacred duty to secure by suitable ligatures, whenever the proceeding is practicable, all wounded arteries of important size before the patients are sent away from his direct observation. In these cases, too, especial care should be taken that the ligatures are firmly and properly applied. A ligature that may remain on an artery, although indifferently secured, when a patient is placed quietly in a hospital bed and is free from all sources of disturbance, may easily become detached through the shaking of transport vehicles over bad roads, or some of the numerous other jarring conditions to which patients are subjected under the rough circumstances inseparable from military operations in time of war, and so give rise to a recurrence of hæmorrhage. In ligaturing a wounded and bleeding artery, it should be remembered that both the upper and lower divisions should be separately secured if the vessel has been completely divided; and that equally, if it be a punctured wound or partial division of the vessel, a ligature should be placed above and below the opening in the vessel, and its complete division afterwards effected. It is only in a case in which, from some cause or other, such proceedings cannot be successfully accomplished, that ligature of the principal artery at a distance from the wound should be resorted to.

As, however, instances frequently occur of gunshot wounds being accompanied with more or less bleeding, or liability to recurrence of bleeding, under circumstances in which it is not possible to ligate the wounded vessels while the patients are in the field in front, and in which the use of tourniquets, therefore,

is compulsory, it may be useful to make some observations on these instruments, with reference to the experience hitherto gained of their employment on active service in campaigning.

Tourniquets for use in the field.—Many of the tourniquets and compressors which have been devised for the temporary arrest of hæmorrhage in civil practice are too bulky, or too liable to get out of order, to answer the requirements of surgical practice in the open field, where portability and simplicity are of extreme importance in all appliances. In field surgery the tourniquets are usually limited to two kinds, which are sufficiently familiar to all surgeons—viz., the simple pad and strap, or 'field tourniquet,' which is supplied in considerable numbers; and the somewhat more complicated 'screw,' or 'Petit's tourniquet.' They are contained in the regulation cases of surgical instruments for use in the field supplied to most, probably to all, armies.

The methods of restraining hæmorrhage by surrounding the limb with a handkerchief and stone in it, or with a band tightened by twisting it round by means of a sword or a stick of wood placed between it and the limb, and other like proceedings, though occasionally recommended as simple contrivances for stopping bleeding, are attended with risks of hazardous consequences when employed on field service; and their use, so far from being encouraged by army surgeons, should be deprecated as dangerous expedients, only to be resorted to under very exceptional circumstances, and when within probably speedy reach of surgical advice. A so-called 'improved elastic tourniquet' was introduced some few years ago with the same dangerous qualities.[2] Fortunately the pain caused by such tight ligatures under ordinary circumstances is so severe that they cannot be retained for any great length of time without very earnest appeals being made to obtain their removal. Help is urgently called for, and thus, if a surgeon or trained attendant can be found, the threatened dangers are prevented.

The ordinary pad, buckle, and band, or 'field tourniquet,' is hardly better in its principle than the contrivances above named. In whatever part of a limb a wound leading to hæmorrhage occurs, even if it be in the hand or the foot, the field tourniquet, when applied, is usually put on at its upper part, because the control of the bleeding is mostly easier and more complete there than at any part below. To be effective it must be tightly applied, and with such constriction the circulation, both superficial and deep, is almost entirely stopped, the limb after a time becomes numbed, and the contractile power of the muscles is weakened. General venous congestion and œdema of the whole limb below the seat of constriction are induced. Deterioration of the condition of the structures penetrated and contused by the shot, especially if it be an extensively lacerated one caused by a shell

fragment, with its devitalised surface and torn tissues, clotting of blood in the surrounding vessels, and other mischief follow. Throughout the whole limb a decline towards loss of vitality takes place according to the degree in which the circulation of blood and nervous energy are arrested by the compression of the instrument, and the length of time the arrest is continued. Thus a very unfavourable condition is brought about for future surgical interference, not only at the seat of injury, as for ligature of a vessel in the wound for example, but even for amputation should it be required, and for the subsequent repair of the stump in case of this latter operation being resorted to. Tourniquets once applied will often be retained for long periods under the usual circumstances of warfare; surgeons can rarely say how long. Where many men are wounded together, where a defeat followed by a pursuit causes a considerable extent of ground, intersected by hedges and ditches, to be passed over by the combatants, or where fighting takes place in a wooded country, it must constantly happen that some men, who are disabled by their wounds from moving away to get assistance, will remain many hours undiscovered and unattended to by the surgeons; and if a wounded limb be left during the whole of this time compressed and strangulated by a tight tourniquet, gangrene will be the almost inevitable result. A soldier, notwithstanding the pain, will, under such circumstances, probably not dare to relax the instrument himself, from fear that death may follow from bleeding. Some American surgeons, owing to the ill results produced by them, have even expressed their conviction that, in the field, it would be less hazardous to leave the wounded to nature, without using any mechanical appliance, than to depend upon the common pad and buckle tourniquet for arresting hæmorrhage.[3] The ill effects of these instruments were said to have been particularly noticed after some of the battles in the early periods of the late American civil war; and the same thing was stated after the great battles of Solferino and Königgrätz, owing to the length of time which elapsed before surgical assistance was given to many of the wounded on whom tourniquets had been applied.

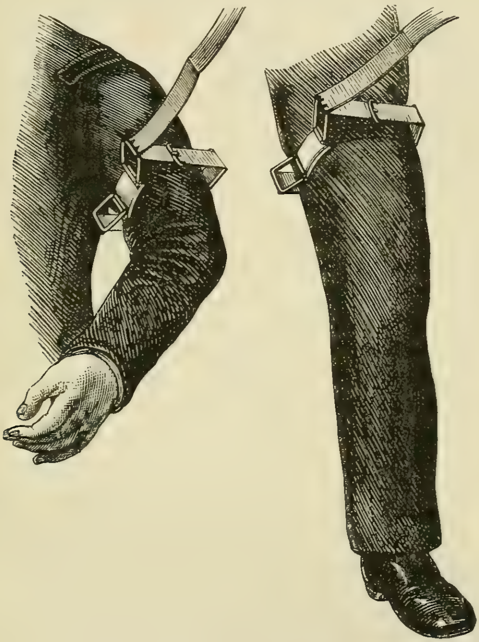
As such instruments cannot, however, be discarded from use in field practice, it becomes important to consider how that which is objectionable in them can be most reduced in amount and effect. It may be accepted as a fact that it is impossible to avoid compressing the main vein at the same time that the main artery is compressed by any form of tourniquet or appliance under the circumstances in which such compression has to be exerted in field surgery. The most that can be hoped for is, while making the necessary pressure to control the bleeding from the wound, that the rest of the circulation of the limb shall be interfered with as little as possible—to contrive that a space shall be left free from

compression, so that the circulation may go on through the collateral smaller vessels of that unimpeded space.

Several field tourniquets have been designed with a view to attain this special advantage.

Lambert's elastic tourniquet.—A field tourniquet, to which the name of the *Elastic Tourniquet* was given,[4] or Lambert's Field Tourniquet, as it was also called, from the name of the inventor, Dr. Lambert, was first brought to notice at the time of the United States war, about the year 1861. This tourniquet consists

FIG. 43.



Lambert's Elastic Field Tourniquet.

of two concave plates of polished metal, and of some elastic as well as of some non-elastic bandage. The two metal plates are of different sizes: the larger being nearly 3 inches in length by 2 inches in width; the smaller nearly 2 inches in both directions. The non-elastic band, which is about 21 inches in length and $1\frac{1}{2}$ in width, is employed to connect the two plates; the elastic band, which consists of a piece of india-rubber webbing about 1 inch in width and about 1 yard long, is buckled on to the end of the non-elastic band. The metal plates act as pads, and are used as the means of pressure to restrain the flow of blood;

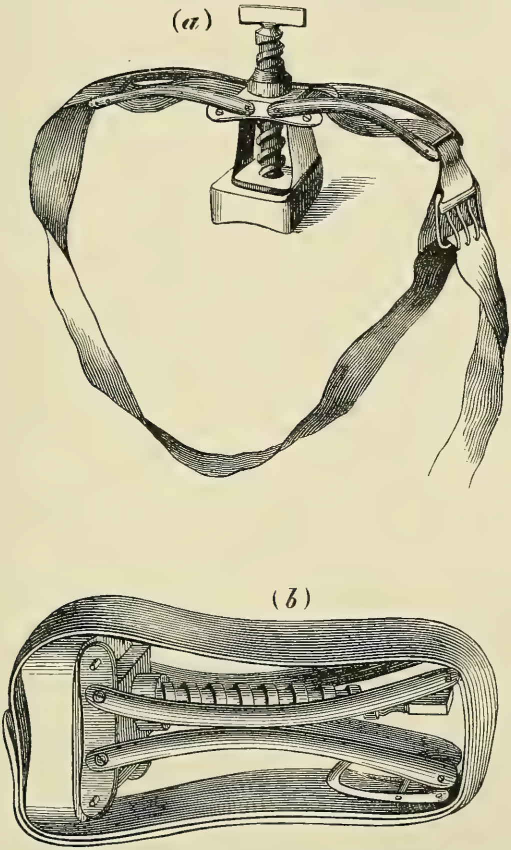
the smaller being placed over the artery, the larger on the side of the limb opposite to it, for counter-pressure. Each of the metal pads is furnished with a pair of projecting wings, made of substantial iron wire, one at each end. The wings move on hinges, and fold completely down upon the pads, while in the other direction their movement is limited. When they are raised and expanded to the utmost extent, they stand out at such angles with the pads that, while they act as supports and as means of fixing the connecting bands, they also prevent the bands from being in contact with the limb which they encircle. The elastic webbing is intended to be passed completely round the tourniquet, and by being put on the stretch, to maintain additional pressure, as occasion may require, by its elasticity. The manner in which the instrument is applied is shown in the foregoing drawings (fig. 43), which are taken from the American pamphlet on the subject.

The essential difference in principle between Lambert's tourniquet and ordinary field tourniquets is the adoption of the wings for the purpose of limiting the compression to two parts of the limb, viz., to the immediate neighbourhood of the main artery, and to the part of the limb opposite, where the counter-pressure is exerted. All the remainder of the limb is intended to be left free from pressure, so as not to interfere with the general circulation through it. Practical trials with this tourniquet have shown that it does answer its intended purposes, especially for the arm, and for the thigh also in moderately developed persons; when a patient is very stout the wings are not so expanded as to prevent all lateral constriction. Other advantages claimed for this tourniquet are that it is simple in construction, portable, quickly and easily applied without assistance (often an important matter in field surgery), steady in position after application, and of inexpensive materials. Several other field tourniquets, including one by Dr. Mott of New York,[5] were invented with projections for obviating the total constriction of a limb; but the one just described seemed to have the advantage of being the handiest and the least liable to accidental displacement after application.

Winged screw tourniquet.—The screw, or Petit's tourniquet, which has long been used in military as well as in civil practice, possesses many advantages. It has great compressing power, and this power can be well regulated by means of the screw adjustment. When the mechanism of the instrument is understood, it is quickly and easily applied; but from being rather complicated in its original form, is liable to be disarranged in unskilful hands. Its chief objection, however, in field practice has been one which is not experienced in civil practice, because it is never used in the latter without constant supervision, viz., the general constriction to which, in common with the ordinary field tourniquet, it subjects a limb from the compression of the whole of its

circumference. To prevent this injurious result, the late Surgeon-Major Moffitt applied wings to it on similar principles to those attached to Lambert's tourniquet. The drawings show the instrument with the wings expanded, and with them folded up. The wings, when open, stretch outwards to each side, so as to give

FIG. 44.



(a) Moffitt's Winged Screw Tourniquet (open); (b) Moffitt's Winged Screw Tourniquet (folded up).

a space of $6\frac{1}{2}$ inches, an extent which exceeds the diameter of a thigh of average size. The compressing pad is made of wood $\frac{1}{2}$ inch thick by 2 inches long and $1\frac{1}{2}$ inch broad, with its under surface concave.[6] The strap is permanently fixed to the upper surface of this pad. When folded up, the instrument forms a

package of $3\frac{3}{4}$ inches long, 2 inches broad, and $1\frac{3}{4}$ inches deep. It is thus sufficiently portable, and, when compared with Petit's tourniquet, will be found to be more simple in construction, owing to the absence of the lower plate, and to the strap being fixed in position. But its great advantage is that while it has the compressing power and capacity for adjustment of the unwinged tourniquet, it is free from the defect of constricting the whole limb, which was inseparable from that appliance.

General distribution of tourniquets.—The necessity for a general distribution of tourniquets among the combatants of an army on active service is so frequently urged by non-professional persons on the occasion of war, and sometimes indeed by surgeons,[7] in order that every one may have the means of checking hæmorrhage always at hand, that it seems necessary to say a few words on this topic. Those who recommend this proceeding seem to think that every gunshot wound is accompanied with such a serious amount of loss of blood that life is endangered from this cause alone, whereas experience tends to show it is only a small proportion of the gunshot wounds in battle which prove fatal simply from excessive primary hæmorrhage. No one can reasonably admit the necessity for furnishing a soldier with a tourniquet to protect himself against the chance of his happening to form one of this number, without equally granting the necessity for providing him with the means of warding off a number of other casualties to which he must be exposed in battle. And were such admissions to be acted upon, it is obvious that the soldier would be so encumbered as to hinder the execution of the very objects for which he has been trained and for which he is employed. But the most serious objection of all to a general distribution of these instruments is that it would probably lead to a considerable amount of positive mischief. Although gunshot wounds are comparatively rarely fatal solely from hæmorrhage, almost every wound is attended with slight oozing or a limited loss of blood. By many uneducated and excited men this bleeding would at once be interpreted as showing the need of a tourniquet; evils already mentioned would result, and thus a simple wound might be converted into a relatively grave one. Others have advocated that the non-commissioned officers of each regiment should carry a certain number of tourniquets, after receiving some training in their application. It is equally questionable whether this arrangement would effect any practical good. It is not likely that tourniquets, if they were carried by non-commissioned officers, could ever be made use of during the progress of an action. They could not, without neglecting their own important duties in the combatant ranks, stop to pay attention to a wounded comrade, even if he were seen to be bleeding profusely. It must unhappily be admitted that the majority of those who have large arteries

opened in such a way as to lead to dangerous hæmorrhage while fighting is going on will succumb as surely, and almost as quickly, as if they had been shot through the heart; while those who are subjected to loss of blood from arteries of inferior importance will be usually saved from fatal hæmorrhage by natural occlusion.

Digital pressure of bleeding vessels in wounds.—The majority of army surgeons altogether disapprove of such instruments, however perfect they may be in construction, being placed in the hands of unskilled soldiers, from a belief that the mischief done by them would be likely to exceed any good that might result from their possession. But even their employment by the bearers trained for carrying and helping the wounded has been opposed by some influential surgeons. They have urged that a better plan is to teach attendants whose duty it is to carry wounded from fields of battle to insert a finger into every wound from which they see a flow of blood, and to keep it there during the period of transport until the aid of a surgeon can be obtained. No doubt all that is required to carry out the temporary arrest of bleeding by the pressure of a finger is a certain amount of care and calmness, and there is no reason to suppose that these qualities will be found wanting after a proper comprehension of the nature and objects of the operation have been acquired; at least not among men who are fitted to be hospital attendants or bearers of wounded from a field of battle. The precise spot where the compression is required, and the degree of pressure necessary, will be quickly made manifest to sight by the effect on the flow of blood. The practice of stopping hæmorrhage by means of a finger inserted into the wound was recommended in the Russian army during the Crimean war, and was said to have been practised with success. Tourniquets were scarcely ever used. The Russian surgeons trained soldiers and stretcher-carriers to put their fingers at once into wounds, and to exert pressure whenever much bleeding from them was observed. Dr. Demme, in his work 'Studies on Military Surgery in the Italian Hospitals in 1859,' mentions that several lives were saved by instructions to the same effect being given to men of the Austrian army in that campaign.[8]

As regards officers and soldiers in the ranks, it certainly seems less objectionable to inculcate the plan of stopping bleeding by pressure of the finger within the wound than to furnish them with tourniquets; for their knowledge of the proper use of such instruments, whatever hints on their employment may be previously given, must always remain exceedingly limited. But there does not appear to be any sufficient reason why tourniquets should not be put into the hands of all trained bearers and hospital attendants. If properly trained, they will understand what to do and what to avoid in applying the instruments; while the application of them

will leave the hands of the men free for performing their carrying work as bearers, or for doing other duties which they could not do when engaged in stopping bleeding by digital pressure. In an urgent case, and in the absence of the necessary instrument, such men would of course understand the mode of stopping hæmorrhage by digital compression, whether within the wound itself or along the course of the principal artery leading to it.

Internal remedies at dressing-stations.—In respect to internal remedies, the only one likely to be required in the field, other than the ordinary diffusible stimulants and restoratives, is morphia. An opiate will often be of use in cases of abdominal wounds, in wounds accompanied with excessive pain or great nervous excitement. Morphia prepared in proper doses, and arranged in small packets, was used with great advantage during the war of the rebellion in the United States; but the use of this drug in solution, administered in the form of a hypodermic injection, has been proved during recent wars to be a source of so much more ready and quick relief in all severely painful wounds, that the necessary injection syringes and morphia solutions for thus employing the drug are now included in all field medical cases.

Index tablets or 'tallies.'—As soon as the necessary attention has been given to a wounded man at a dressing-station, especially if any surgical operation has been performed, such as the ligature of an artery, the removal of a missile, or if a morphia injection or dose of opium has been administered, the name and designation of the patient, together with a description, as brief as possible, of the situation of the wound, and of what has been done, should be written under the proper headings on one of the 'tallies' provided for the purpose. The tally can be filled up by an attendant at the dictation of the surgeon, and when signed, should be carefully attached to a button or some conspicuous part of the soldier's tunic. It is to be remembered that the object of the tally and of the information given on it is to prevent needless re-examination of the wound while the patient is on his way to the field hospital or after he reaches it, as well as to direct the attention of the surgeon under whose care he may be placed on his arrival to any circumstance which it may be important for him to be aware of in the man's interest, or as affecting the subsequent treatment of his wound. Three or four words will generally suffice to give the indications referred to, and the few moments spent in writing them will be fully repaid by time saved subsequently, as well as by the advantages resulting to the patients. The form of these field tallies is described elsewhere in the chapter on Field Equipment.

CHAPTER II

GENERAL TREATMENT OF WOUNDED MEN ON REACHING A FIELD HOSPITAL

In the preceding chapter the chief points to be noted in the preliminary treatment of gunshot wounds on the field of action have been described; their further treatment, as soon as the wounded men have arrived at a field hospital, will now be considered. The name, regiment, regimental number, and general nature of the injury of each patient, taken from the tally label attached to the man's uniform, or from observation at the time he is brought in, should be briefly registered for future reference in the Admission and Discharge Book by some one deputed for this special duty; and as soon as circumstances admit of its being done, if not already done, a proper and complete diagnosis of each wound and injury should be established, and its treatment systematically settled and commenced. It is not possible to make a definite classification of the wounded while they are being brought in quick succession to the field hospital, but an approach to one may be made, so far as noting whether the examination instituted at the dressing-station, and dressing applied there, suffice for present needs; whether an examination of the wound for diagnosis, or for settling matters of treatment, is still required, or whether the necessity for some important surgical operation appears to be urgently indicated. The patients can then be distributed in accordance with these several categories, and dealt with in regular order by the surgeons engaged in the treatment. An important point in a field hospital is to keep lists ready of those who have been attended to, and are in a suitable condition for being sent away whenever an order, however sudden, for the evacuation of a portion of the patients may be received, and of those who are not in a fit condition for removal.

Arrangements according to the accommodation at field hospitals.—Some of the arrangements for the custody and care of the wounded, and for the surgical management of their injuries, will necessarily vary according to the position and circumstances of a field hospital—especially its distance from the front, the nature of the accommodation afforded by it, and whether it is within easy distance of a highroad, railroad, or navigable water, affording ready facilities for the evacuation of patients. If it be established at a farm or a country house at no very great distance from the scene of action, as will often happen in European warfare, it will soon become overcrowded; and some of the wounded, after having had their injuries attended to, will probably in a

short time have to be removed to other hospitals farther in the rear. Many of the wounded as they arrive will have to be laid on straw on the floors of rooms, in barns and outhouses, under any shelter that may be available, or on ground in the open air. If it be established at a warehouse or other large building in a village or town, better accommodation will perhaps be got, some bedsteads will probably be available, and more complete hospital arrangements can be established. If only a few bedsteads can be obtained, these should be reserved for cases of badly fractured limbs and for those in which amputations or other grave operations are performed. The difficulties in their treatment will be greatly enhanced if the patients are lying on the ground. In other cases temporary bedding should be provided by means of mattresses of straw, hay, or any other convenient material, laid upon the floors. Some proceedings will have to be modified in proportion to the time the patients are likely to be able to remain in the field hospital. It will be useless to remove all the clothes of men who will have to leave the hospital beds within a few hours, or even within a day or two, after their admission. If, on the contrary, there is a fair prospect of the patients being able to remain under treatment in the same place for several weeks, they will be placed systematically on their beds, will in turn have their clothes carefully removed, first from those parts of the body which are not injured, and next from those parts in which the fracture or other injury is situated; in short, the patients will be treated and placed as nearly as possible under the same conditions as they would be were they admitted for treatment in a fixed hospital. Other circumstances, which are noticed in the chapters on Transport of Wounded, Equipment of Field Hospitals, and Field-Hospital Administration, will perforce modify the decisions of surgeons as to the proper treatment to be adopted in particular instances of gunshot wounds. The description of the hospital treatment of gunshot injuries, in this and in the following chapter, is only intended to afford information on the general plan to be followed when and so far as circumstances admit of its application. In the practice of field surgery, military surgeons are compelled to resort to all sorts of shifts to ensure the welfare of their patients, and these expedients must vary according to the peculiar conditions in which they find their patients placed at the time they require professional assistance.

Persistent shock.—Should a wounded man, on being carried into the hospital, be found to be still labouring under shock, and this shock is of an extreme character, it must not be forgotten that the condition of the patient is one of great hazard from this cause alone, and that special attention must be given to extricating him from it. All practicable efforts should be made to equalise the circulation, to restore warmth to the body, and to increase sensi-

bility as speedily as possible, but at the same time very cautiously, and with no undue disturbance of the patient. Caution is required lest in trying to restore vital action the remedies applied may cause the reduced powers of the patient to be strained beyond endurance, and so the remedies themselves cause death. The heart that is scarcely acting, if subjected to excess of stimulation, may cease to act altogether. The judgment of the surgeon will always be greatly taxed in severe cases of shock; not so much in respect to the nature of the remedies to be employed, as in respect to the extent to which he can employ them with safety. His difficulties are increased when the shock arises from a wound in itself of extreme gravity, or when it is aggravated by collapse from hæmorrhage. When the last-named complication exists, the case becomes one in which the operation of transfusion of blood may be attended with benefit. In all cases of shock, freedom from constriction of the surface of the body and the maintenance of a perfectly horizontal position are essential. Nature sufficiently indicates the necessity of this injunction. If the upper part of the body of a patient suffering from extreme shock be carelessly elevated, it may happen that life will shortly be extinguished, for the heart may become overloaded, and respiration cease. Artificial warmth should be applied to the body of the patient in any way most handy, due consideration being given to the nature of the wound or injury which is the source of the collapsed state of the patient. Hot water, which should be got ready by the men of the medical staff corps as soon as the site of the field hospital is determined, for use in preparing nutrient drinks and for various surgical purposes, may be applied in bottles to the legs, and in metal warmers to the abdomen. Wrapping in blankets may be serviceable for the purpose. At the same time, while applying artificial warmth to the body, fresh air should be freely admitted to the patient's face. If he can swallow, the administration of a little brandy by a spoon from time to time, sufficient to maintain the heart's action without exciting it unduly, is valuable; or, if deglutition cannot be performed, the advisability of the administration of a subcutaneous injection of ether, or a stimulating enema, should be considered. After a time, if consciousness of pain in the parts wounded be exhibited, or if any interest be taken in surrounding circumstances, these will be signs that the efforts to remove the effects of shock are being followed by success. As soon as this amount of improvement occurs, perhaps a little simple nourishment, such as beef essence, may be taken, and this will prove valuable as a further restorative. On no account should opium in any form be administered to a patient in a state of extreme shock or severe collapse; even a minute dose under such circumstances may lead to a fatal result. Nor should any surgical operation of a grave kind ever be undertaken before

a patient labouring under extreme shock begins to rally from it, and exhibits some return of general and local sensibility. The wound itself, however extensive and serious, provided it be free from hæmorrhage, does not call so urgently for notice under such circumstances as the constitutional condition of the patient.

Temporarily arrested hæmorrhage.—If the surgeon finds that a wound has been plugged or that other local means have been used for the control of hæmorrhage, and especially if the required notice is given on the tally ticket of the dressings having been applied with this view at the dressing-station, while no fresh symptom has since occurred to call for special interference, the patient should be placed where he can remain quiet for some time, so that he may be disturbed as little as possible; at the same time, the treatment already adopted for securing closure of the divided vessels should be seconded by perfect rest of the injured part in a favourable posture, that is, one in which the structures involved in the wound are relieved from all strain, pressure, or call for action. The application of cold, and generally the administration of an opiate, may also be advantageously resorted to. On the next day, or before, if symptoms occur to indicate a need for the interference of the surgeon, the pressure may be relaxed, and if the tendency to bleeding appears to have been arrested, the ordinary treatment of the wound may be proceeded with. If the hæmorrhage recur, it will then have to be dealt with according to the situation of the source of the bleeding, and the particular circumstances of the case.

Primary hospital treatment of gunshot wounds in general.—But supposing that the patients brought in are free from intense shock and tendency to active hæmorrhage; that any shock which is present exists only in a moderate degree; that, if weakened by exposure, pain, or the effects of a long transport in a jolting vehicle, some suitable restoratives have been administered; and presuming further that the nature of the injury has not already been determined, and is not sufficiently obvious without further examination; the following are the points to which the surgeon should give his attention as he visits the wounded in succession:—

1. Examination and exploration of the wound with a view to establish a definite knowledge of its nature, extent, and complications, and to determine the operative proceedings to be adopted if any are found necessary;

2. Removal of any foreign bodies which may have lodged;

3. Adjustment of lacerated structures if the wound be of a kind to require it;

4. If not told off for immediate surgical operation of importance, the disinfection of the wound and surrounding parts, and the application of the primary dressings.

The constitutional treatment, the proper kinds and quantities of nourishment to be administered, the successive local applications, as a case of gunshot injury progresses through its successive stages, are matters for subsequent consideration.

It will be convenient to keep chiefly in view, first, the treatment of such injuries as are caused by the smaller kinds of missiles, such as rifle projectiles and shell fragments of limited dimensions, and afterwards of those resulting from heavy projectiles of larger sizes.

In order that a wound may be satisfactorily examined, it must be fully exposed, temporary dressings that may have been applied hastily on the field being gently removed, any dust, dirt, or clot that has become collected in its neighbourhood carefully cleared away, and the surrounding integument cleaned and purified by an antiseptic lotion. If the wound be on the head or on a part of the body covered with hair, this should be removed from its neighbourhood. When the injured part has been thoroughly cleansed, and the wound is fully exposed to observation, the nature and extent of the injury inflicted should be accurately established. In occasional instances, especially in cases of perforating flesh wounds by rifle-shot, the openings may be so well occluded by antiseptic dressings which have been applied in the front, and the wounds may be so manifestly free from all important complications, that it would be only a wasteful disposal of time to interfere with them. They can be left without further examination, due attention being given that rest of the injured parts is secured, so long as they remain free from pain and any fresh symptom demanding surgical attention.

Early diagnosis very important.—In all cases of shot wounds in which there are elements of doubt respecting the amount and limits of the damage done by the shot, existing complications, and therefore of the required treatment, a settlement of the questions involved should be arrived at as soon as possible after the arrival of a patient at a field hospital. The importance of complying with this precept cannot be overrated. A complete examination of the wound can be made with less suffering to the patient and more satisfactorily to the surgeon at that time than at any later period. The sensibility of the parts adjoining the track of the missile is to a certain extent numbed before reaction is established; and there is less swelling to interfere with the examination, so that the amount of disturbance effected among the several anatomical structures, as well as the lodgment of any foreign bodies among them, are more obviously apparent than they will be subsequently. Moreover, the examination, if judiciously conducted, with a due appreciation of the importance of excluding and guarding against all septic influences, is at this period free from deleterious effects; while the same proceeding, if it be put-

into practice after inflammatory action has set in, is positively injurious, and even liable to prove dangerous in its consequences. It is the time, too, when the patient will generally submit to a thorough examination with the most readiness; his courage has not yet been lessened by protracted pain and confinement, while natural anxiety to learn his fate, or to ascertain the extent of the accident which has befallen him, stimulates him to support any pain that may accompany the ordeal.

It may be well to observe, by way of caution, that whatever conclusion a surgeon may come to in his own mind respecting the nature and extent of a gunshot wound at the first examination, it is always prudent to avoid making a positive statement on the subject to the patient or his friends, unless the wound be one in which the limits of the mischief done by the projectile are quite obvious to touch or sight. In no class of injuries has there been a greater proportionate number of mistakes in diagnosis and prognosis than there has been in gunshot injuries. It is impossible for a surgeon not to form an opinion regarding the nature of a wound as soon as it is exposed to his view; but, if experienced, he will be so aware what deeply seated mischief may exist though unsuspected, what complications without direct and immediate manifestation of their effects, that he will always be on his guard as to making a positive statement on any case open at all to doubt. Such hesitation will not be likely to have any hurtful effect on the mind of a thoughtful patient, although he may be most anxious to learn what will be the issue of his wound; he will rather appreciate a cautious opinion on the part of the surgeon at its proper value, and probably be impressed with more reliance on his judgment and ability than if he had received a definite announcement on his case after an obviously hurried and what he may consider incomplete examination. If there be sufficient ground after due observation for removing a patient's apprehensions, it ought to be done by all means; but if any uncertainty exists, the opinion given ought always to be a guarded one, notwithstanding the temptation to make an absolute declaration on the subject. I have known very unpleasant results happen from want of caution in this respect.

It is on these accounts that the examination of each patient, as well as the diagnosis of his injury, should be made by the senior surgeon in charge of the field hospital, or by an experienced surgeon whom he has told off for the duty. When the diagnosis has been properly established, if the injury has been found to be a simple one, or if any complications that may have accompanied it have been attended to and rectified, the patient may safely be handed over to one of the junior surgeons, or to one of the trained attendants, for the application of the established dressings; if, however, the case be a complicated one, or require special atten-

tion, the necessity for its treatment by an experienced medical officer will be sufficiently apparent. The applications for relief at the field hospitals after an action are generally very numerous, pressing, and apt to be confusing, so that a systematic plan of conduct under authority of the directing surgeon is essential, in order that the disposal of the patients may be expeditiously managed, and at the same time accomplished satisfactorily from a professional point of view.

Mode of examining gunshot wounds.—One of the oldest rules for examining a wound in which a bullet or other projectile of limited size has penetrated and passed out of sight, is to place the patient in a position, as nearly as can be ascertained, similar to that in which he was in relation to the missile at the time he was struck by it. This rule is as valuable now as it was found to be centuries ago; perhaps even more so, since modern rifle projectiles are so much less liable to be deflected by accidental circumstances from a definite line of direction in passing through parts of the body than the bullets employed in former days.[9] In almost every instance in which the rule can be carried out without injury or inconvenience to the wounded man, a knowledge of the true path of the missile, and conclusions in respect to the proper treatment, will be facilitated by attention to it. Occasionally it will afford proof that separate wounds at a distance apart from each other have been inflicted by one and the same missile; or if a projectile has lodged, it will lead to the discovery of the place of lodgment; or if it has made a direct escape, will be the means of indicating the probability of injury to the surface of a bone, to a joint or some other important structure, when the mutual relations of the wounds of entrance and exit would lead to no such information, or in which the altered positions of tendons and muscles overlying the deeper sites of injury would prevent the information from being obtained in either the erect or horizontal posture of the body. The course the projectile has taken may be one in which an important blood-vessel can scarcely have escaped from contusion, leading to the liability of secondary hæmorrhage or gangrene; a complication which may not be suspected, without attention to the above-named rule, on the first admission of a patient into hospital.

A surgeon has only to observe the variety of attitudes in which men place themselves when advancing as skirmishers against a supposed enemy—to watch them creeping along the ground, lying prone or doubled up under some slight cover while firing, and assuming other postures in order to obtain as much shelter and protection as practicable in exposed situations—and then to consider the probable courses that bullets discharged by an enemy in front would take on striking these men in the most exposed parts of their limbs or bodies, in order to understand how impossible

it would be to explain the direction of some of the wounds produced under such circumstances without knowing the positions the patients were in at the time they received their injuries. It will be equally evident how little a surgeon, without the same knowledge, may be able to form an opinion of the injury done by a projectile which has entered without passing out again; how little the position of the single opening can guide him to a knowledge of the course taken by the bullet or its site of lodgment.

Even in cases where the condition of the patient, or the nature of his wounds, renders it impracticable or unadvisable to place him in the same posture as he was in at the time he was wounded, the inquiry should always be made as to what that posture was. If a correct reply can be obtained from the patient or a spectator, a skilled surgeon will be better able to form an opinion as to the particular structures it may have damaged in its passage.

Examination of clothes.—Whether one or two openings have been left by the projectile, the uniform and underclothes of the patient should be examined at the time they are taken off, whenever circumstances permit; the inspection of the uniform or accoutrements worn over the part wounded may serve as a guide in determining whether a fragment of shell, a bullet, or other foreign substance has entered and passed through or not, and if so, its direction. If a bullet has traversed the parts over which the clothes were worn, the relative sizes of the openings in them will usually show at which the projectile has entered, and through which it has passed out. They will also indicate whether the wound is only a flesh wound, or whether a bone has been struck by the missile in its passage: in the former case, the two openings will usually be nearly alike in size; in the latter, the opening through which the bullet made its exit will usually be the larger and more torn of the two. A hint may thus be obtained influencing after-proceedings, time may be saved and some pain prevented in the subsequent examination of the wound itself.

The examination of the clothes having been made, and very little time need be occupied in making it, particular attention should next be turned to the wound itself. If a wound is plainly a simple flesh wound, or of such a character that its whole condition is obvious on mere inspection and palpation, a further exploration of it is not necessary and should not be made, nor should it be, simply because a shot has penetrated one of the cavities of the body, for under ordinary circumstances it would be a probable source of mischief. The grave operation of exploring the cavity of the abdomen by abdominal section in order to solve uncertainty regarding the lesions inflicted by a shot, and the surgical proceedings to be pursued in accordance with what may be discovered, is not such a general exploration for diagnostic purposes as is at present under consideration; it is a subject

which properly belongs to the question of the treatment of penetrating wounds of the abdomen. But in a simple flesh wound by gunshot, although the general rule is that the less a wound is interfered with in the way of examination the better, if a complete knowledge of its condition, or if any useful information regarding it which is wanting, can only be obtained by a technical exploration, it should be immediately made, and this can be done, not only without any ill results, but with much advantage, if it be executed with the necessary judgment and caution.

Exploration of a gunshot wound.—Two objects are to be kept in view in exploring a shot wound: one is the establishment of a correct diagnosis as to its limits and to its nature—whether it is simple in character, or accompanied with injury to bone or other important structures which affect its treatment; the other is to determine if the injury be complicated with the lodgment of the projectile by which it has been inflicted, or of any other foreign bodies carried in by it, when there is good reason for supposing such a complication may exist. If the wound be one in which there is no ground for suspecting injury to bone or other structures of prime importance, the examination may still have to be made to determine the question of lodgment; and should this be done, we should always, at the same time, definitely establish the fact that the wound is the simple one we suppose it to be. Both the points at issue, the extent and nature of the wound in respect to structural complications, and the question of lodgment of foreign bodies, ought to be solved by one and the same examination.

When only one opening has been made by a projectile, it is to be presumed that it is lodged somewhere in the wound, and search must be made for it accordingly. The only exception is when it is known that it has escaped from the wound of entrance—a rare occurrence—during the movements of the patient on his way to the hospital. But even when two openings exist, in any case of doubt the examination should be made to determine the extent and nature of the wound with accuracy, and to detect the presence of other foreign bodies exclusive of the missile itself, especially when the appearance of the clothing or of other articles has indicated that portions have been detached from them. This necessity will scarcely ever occur in a case of flesh wound inflicted by a modern narrow rifle bullet, so trifling is the portion of clothing usually detached by it at the opening of its entrance, but will often happen when the wound has been caused by a fragment of shell or shrapnel shot.

The foregoing, as well as the subsequent remarks on the extraction of foreign bodies from wounds, only apply to the cases in which the patients are brought to the field hospitals within a few hours after their wounds have been inflicted, before inflamma-

tion has occurred. If from any cause the admission of the patient has been so long deferred that the seat of injury has become swollen and inflamed, even though the surgeon may be told that a missile or clothing is lodged in the wound, it is better, as a general rule, to delay the exploration until a later period. The only exception to this rule should be a case where the foreign body is so placed that it can be removed at once without any difficulty. To explore a long or tortuous track when the parts are in a condition of active inflammation would not only be a difficult proceeding on account of the swollen state of the tissues, but would cause great pain, aggravate the existing inflammation, and in occasional instances might give rise to an amount of nerve-irritation, the subsequent effects of which would get beyond control. My former colleague, Professor Maclean, as I have elsewhere mentioned, saw a series of cases of tetanus occur among wounded soldiers in China; and in all these instances the wounds had been explored while they were in the first stage of inflammatory excitement.

Exploration by the surgeon's finger.—Of all instruments for making a complete examination of a gunshot wound when necessary, as well as for exploring for foreign bodies which may be lodged in it, the finger of the surgeon is the most appropriate, whenever a wound is large enough, or has been rendered so by suitable incision, to admit of its insertion. By its means the direction and limits of the wound, as well when it is devious as when it is direct, can be ascertained with least disturbance to the several structures through which it takes its course, and the true condition of the injured structures most thoroughly noted. If there be an obstruction to the progress of the finger, and it arises from a tendon which has come into the line of the track of the missile, or from a layer of tendinous aponeurosis, or from any similar barrier, the nature of the impediment can be felt, and it can be moved aside or otherwise avoided. If a bone is fractured, the number, shapes, lengths, positions, and degrees of looseness of the fragments may be more readily observed. If a bone has been denuded of its periosteum, chipped, or grooved, the sensation of a finger will communicate information of what has occurred. Exploration by a finger will establish the fact of the capsule of a joint being opened, and of the bone being damaged in some cases in which, without the digital exploration, or if a probe had been used instead, the injury to the articulation would have remained a matter of doubt. When foreign bodies are lodged among the soft tissues, not only is their presence more obvious to the finger direct than through the agency of a probe or other metallic instrument, but by its means intelligence of their qualities may also be communicated. A piece of cloth lying in a wound is recognised at once by a finger; while, saturated with clot as it is under such circumstances, it will probably be mistaken for some of the natural soft parts by

any other mode of examination, and be left undiscovered. The index finger naturally occurs as the most convenient in this employment. If the opening through the skin and fascia is too contracted to admit of its ready entrance, it should not be forced in, but an incision to the necessary extent should be made at the margin of the opening extending through the fascia, to facilitate its ingress. An incision, even if extensive, cannot be productive of any harm if judiciously made with due antiseptic precautions; on the contrary, may often prove very useful in opening readier means of escape for discharges. When the finger after insertion fails to reach sufficiently far, owing to the depth of the wound, the examination is often facilitated by pressing the soft parts, especially if the wound be in one of the extremities, from an opposite direction towards the finger-end. The finger, in making the exploration, should be inserted slowly and steadily towards the deepest part of the wound. During its passage the surgeon should carefully observe whether any foreign body appears to be pushed before it, or to be lying by the side of the track of the bullet, and should note any other particular features that may be presented to it. He should also ascertain whether the end of the track is reached; and if this is found to have been arrived at, a careful rotatory movement of the finger, with a circular sweep of its extremity, will then usually determine if any and what foreign bodies are lodged. The surgeon should not withdraw his finger until the course the projectile has taken, the injury it has done, the complications of the wound, such as the presence of foreign bodies, and, in such a case, their kind and situation, have been settled in his mind; the exploration will thus be completed by one operation, and a second insertion of the finger for the purpose, which is always irritating to a patient, will be avoided. Nothing can be simpler than the exploration of a gunshot wound by the finger; yet, simple as it is, very different results may follow the operation according to the manner in which it is performed: if done carelessly and impulsively, it will be done roughly, will cause proportionate bruising, pain, and, after all, convey only imperfect information; if done thoughtfully, these hurtful effects will be avoided, while the knowledge conveyed by the manipulation to the surgeon will be definite and complete. It seems hardly necessary to observe that when making an exploration of the kind in the field, where sources of impurity are so abundant, very strict care has to be taken to prevent the introduction of septic matters into the wound by the explorer's finger or by the fingers of assistants.

Exploration by a probe.—If the finger be not sufficiently long to reach the bottom of the wound, even when the soft parts have been made to approximate by pressure from an opposite direction, and when the lodgment of a foreign body is still suspected, or some other point of doubt remains to be solved, such as the direction

a projectile has taken in the latter part of its course, the surgeon is compelled to make his further exploration by other means. Under ordinary circumstances a long silver probe, that admits of being bent by the hand if required, and that can be guided into a definite direction at the will of the surgeon, is perhaps the best substitute for the finger. Elastic bougies or catheters are apt to become curled among the soft parts, and do not convey to the sense of touch the same amount of information as metallic instruments do. The probe should be employed with great discretion, for without care it may readily inflict injury to vessels or other structures which have escaped from direct contact with the bullet, and have returned by their elasticity to the situations from which they had been pushed or drawn aside during its passage. It should be understood that these directions for examining wounds apply only to those which are in the extremities, or penetrate superficially other parts of the body.

Neglect of early exploration of wounds.—This is not the place to describe the points to be attended to in establishing an exact diagnosis of particular injuries; these can only be properly considered in works in which the wounds of special regions are particularly studied. What I have most wished to call attention to is the general necessity of making a digital examination of a gunshot wound in all cases suitable for the purpose, and of forming as complete a diagnosis of it as possible, at the earliest opportunity a surgeon has of doing so.

It may appear that I have dwelt unnecessarily long in the remarks above made on this subject, and have exaggerated its importance. But the military surgeon's experience in general hospitals shows how frequently these rules, so simple, are neglected; and, moreover, at the same time serves to prove how much the results of the treatment of an injury, and how much, as a consequence, the comfort, nay, even the safety of a patient may depend on their having been attended to or neglected. It has not unfrequently happened, in the British service, that wounded soldiers, after having received their primary dressings at a field hospital, have been compelled by circumstances to be sent on the same day, or the day after the action in which they have been wounded, to general hospitals far in rear of the scene of conflict. In extra-European warfare two or three days may be occupied in the conveyance of the patients by the transport vehicles; or they may have to be removed, after the delay of only a day or two, to hospital ships or transports for removal by sea to general hospitals at a remote distance from the theatre of conflict. Under such circumstances, by the time the patients reach the general hospitals, the opportunity of making a digital examination is gone: inflammation, swelling, excessive sensitiveness in the neighbourhood of the wound, as well as a general condition of constitutional irri-

tation, have supervened; and the exploration, which could have been readily made and easily borne in the field hospital, is no longer practicable. The diagnosis may now have to remain uncertain until some time has elapsed; most probably until suppuration has become fully established. The injury may be one in which to have rendered the wounded part as immovable as possible—an opened joint for example, was of essential importance; or one for which a primary amputation, resection, or other surgical operation would have offered the best hope of safety to the patient; but, under the circumstances mentioned, the time when the precautionary measures would have been of most value has been lost, and the opportunity of performing the primary operation has gone by. Foreign substances, increasing the local irritation, may be lying among the injured structures; but there they must remain until a more advanced condition of the wound admits of their being searched for, and, if then found, of being removed.[10]

Special modes of exploring wounds.—In most gunshot wounds there will be no difficulty in detecting the lodgment of foreign bodies, especially heavy ones, such as fragments of shell, when the examination has been made early by the finger in the way which has been described. If a projectile, which there is good reason for believing has lodged, cannot be discovered in the immediate neighbourhood of the apparent limits of the wound, it should not be forgotten that accidental postures of men often cause projectiles to be carried to long distances away from the spots where they entered. The sensations of patients should be particularly consulted in these cases. Sometimes, when the usual means have failed to find a lodged projectile, the particular place where it is lying may be detected simply by relaxing the muscular tissues, so as to give a loose and pendulous condition to the parts concerned, and then lightly tossing up the flesh at different points from below with the tips of the fingers. The missile, if lodged among the soft parts, will occasionally make its presence known, under this action, by the impulse which its weight communicates to the top of one of the fingers when the parts which have been shaken upwards return to their previous position. Sometimes a gentle kneading pressure in the neighbourhood of the injury, assisted by information derived from the sensations of the patient, will lead to the detection of such a foreign body. Sometimes, as mentioned in the English Official History of the Crimean war, when a lodged bullet could not be detected otherwise, it was found by passing the flat palm of the hand down the limb. It was occasionally detected in this way when the points of the fingers had failed to discover it. In certain particular cases, however, difficulties arise in settling questions concerning the suspected lodgment of missiles, especially such as have been fired by half-civilised enemies, that cannot be mastered by such simple plans, and then

other special means have to be resorted to for solving them. These cases will be considered when the exploring instruments which have been specially invented for the purpose are described.

General rules for extraction of foreign bodies.—As soon as the presence of a bullet or of any other foreign body is definitely ascertained, it may be laid down as a general rule that it is to be removed as speedily as possible by the most easy and direct route.

Every reasonable effort should be made to extract foreign bodies lodging in wounds on their first coming under a surgeon's care, *i.e.*, before the period of reaction. The surgeon should follow this rule, because, in a large proportion of cases, it is easier to remove them at this early period than it is at a later time; because, in the large majority of instances, lodged foreign bodies, as has been particularly shown elsewhere, lead to much inconvenience, frequently to suffering, and sometimes to disastrous consequences, while it is only in exceptional cases that they remain lodged in the human frame with impunity; because the removal is always a source of mental satisfaction to a wounded soldier; and lastly, because, even though a lodged foreign body may happen to be brought away naturally during the progress of cure of the wound, this often happens at the expense of protracted suppuration, and at the risk of various complications which might have been avoided if the surgeon had succeeded in effecting the removal of the source of irritation at the outset of the treatment. Some surgeons of eminence have opposed this general principle of treatment, as they have done that of the early exploration of wounds. They have considered that harm, especially the danger of infection, results from the preliminary incisions and examination, as well as from the efforts to extract foreign bodies unless they are lying plainly exposed to view; while, if they are left alone, they will either make their way out of themselves without inconvenience during the process of suppuration, or, if this mode of escape should fail, will remain lodged without causing much, if any, inconvenience to the patient. My own experience does not confirm these statements, and I believe that most surgeons of the present day regard the advantages of early extraction of foreign bodies as outweighing any disadvantages of the operation for extraction, provided the operation be prudently and judiciously performed.

Of course the rule of taking steps to procure immediate extraction is only to be applied within reasonable limits. It is not intended that it should be acted upon irrespective of other considerations. If a foreign body is lying in a situation adjoining an important cavity, and it becomes a question whether the effort to extract it may not inflict mischief by forcing it into a position out of reach, or if it be lying among injured parts which ought not to

be disturbed, the attempts to remove it had perhaps better be desisted from. But even in such instances the very fact of a foreign body being known to be in a hazardous or objectionable situation is all the more reason for its removal from it; and it really becomes rather a question regarding the anatomical knowledge and operative skill of the surgeon, than of the propriety of the extraction of the foreign body. Again, a bullet may be lying in such a situation that from its depth, or from the tortuous course it has taken, it cannot be extracted by the opening of entrance, while either the time or circumstances may render it unadvisable to undertake a cutting operation for its removal. These, however, are exceptional occurrences, which must be taken into account when the particular cases concerned fall under the notice of surgeons; they do not destroy the propriety of the general rule for the immediate extraction of lodged foreign bodies when wounds with such complications are first brought to the notice of surgeons at field hospitals.

Instances will occasionally occur in which a surgeon will meet with reiterated failures in his attempts to extract a foreign body, notwithstanding that the site of its lodgment is known. If the fatigue and pain of the operation threaten to exhaust the patient's power of endurance, or the repeated attempts at extraction are causing injury to the parts concerned in the track of the projectile, common prudence dictates that the efforts should be desisted from. No rule can be given as to the precise period when attempts at extraction should be stopped in such instances. The time will vary with the particular features of each case, and also with the operative skill and dexterity of the surgeon. A wise surgeon will of his own accord see when the time has come at which due consideration of the circumstances before him compels him to stop further attempts at extraction.

Manipulation for extraction of foreign bodies.—If the foreign body should happen to be lying within reach by the wound of entrance, it should be extracted direct through this opening by an appropriate instrument. An ordinary dressing forceps will suffice for extracting it when it is near the opening, or the forefinger of the surgeon, either alone or with the aid of a steel director, will equally answer the purpose. If the situation of the foreign body be deep, but not so deep as to be felt on the opposite side of the limb or part where it effected its entrance, the extraction should be made by some one of the regular bullet-extractors described farther on, and the operation conducted with more caution and skill, as the finger cannot in such a case be employed as a guide.

The operation of extracting a missile which is lodged among muscular tissues a short distance from the surface is an easy matter enough. But when lodged deeply it often requires more adroitness and patience than a theoretical consideration of the

matter would lead a surgeon to anticipate. The ease with which a hard and smooth projectile eludes the attempts made to grasp it, and slips aside into the soft tissues among which it is lying; the frequency with which some of these mobile tissues get before the instrument and impede the prehension of the missile itself; the liability of bullets, after they have become deformed, as well as of all foreign bodies of jagged and irregular outlines, to be caught and held firmly by some of the surrounding tissues;—these are common sources of difficulty in the way of extracting lodged projectiles. Moreover, a recollection of the sinuous and irregular directions of the tracks which are often left by missiles through parts of the body; of the varied forms and dimensions of the openings left by them in different anatomical structures, especially the slit-like openings frequently met with in fascial and muscular aponeuroses; of the ease with which parts of the soft tissues may be pushed in front of an unyielding instrument; together with the tendency of the perforated structures to alter their relative positions before inflammatory adhesions have occurred among them—will further explain some of the impediments which are often encountered even in early attempts to grasp deeply lodged foreign bodies, or to withdraw them from their places of lodgment after they have been grasped. When foreign bodies have been lodged for lengthened periods, other obstacles arise in the way of their extraction; but these are not met with in recent wounds.

Most English surgeons have hitherto used for extracting such relatively small projectiles as rifle and pistol bullets a two-bladed forceps, or the instrument known in England as 'Coxeter's bullet-extractor,' and have followed the rule of removing them by the shortest and surest channel. The forceps has been most generally employed for the purpose, though Coxeter's extractor has the advantage of distending the track less, as will be explained in the description of the instrument. Whichever be used, it will generally be found necessary to enlarge the entrance opening of one of these small projectiles by incision, if this has not been already done for facilitating the exploration of the wound. The opening in the fascia will particularly require to be dilated. If the track of the bullet be very narrow, as it will always be in a flesh wound by one of the present small-bore rifle bullets, it may be essential to incise some parts of it also; but this can only be a most exceptional occurrence, since such missiles can scarcely ever remain lodged, as before mentioned, owing to their enormous penetrative power. The finger, when the track is free enough, should be inserted alone, and the position of the bullet thoroughly recognised; and while the end of the finger remains in contact with it, the instrument should be passed along the wound by the side of the finger, which will then act as a guide. The blades of the forceps should now be opened, and the bullet fixed between

them, the finger-nail being used for the purpose of pushing aside any soft tissue that might otherwise be caught between either blade and the bullet. The same manœuvre should be performed by the end of the finger in gradually clearing the way for the scoop of Coxeter's extractor to get behind the bullet, and for afterwards fixing it in position by the points of the stem of the instrument. Deliberate effort should be made to get a firm hold of the missile before any further proceeding is attempted. As soon as the bullet is felt to be well secured by either instrument, the finger is slowly withdrawn, and then by careful and steady manipulation to prevent the bullet, especially if it be altered in shape, from being caught by some of the tissues through which the instrument holding it has to pass, or from catching others of importance, which may be lying by the side of the track, the foreign body should be gradually extracted. In a wound in which there is not space enough to admit both the finger and the extractor, the instrument can only be inserted after the finger is withdrawn; but the operation is seldom so quickly or so satisfactorily performed as it is when the finger can be employed as a guide to the passage of the instrument, and as a means of determining that the missile alone is grasped by it. When a forceps is employed, there is always the liability of some of the soft tissues being included in the triangular space bounded by the two arms of the forceps and the projectile which is grasped by its blades, and if so included, it is not possible to extract the projectile without the tissue being torn asunder. When the forefinger is within the wound in addition to the forceps, this occurrence can readily be prevented, and the blades cleared from all beside the foreign body to be removed.

In any case when the insertion of the finger has not been admissible, and the character of the resistance offered to the withdrawal of the projectile is such as to lead to a suspicion that something else has been grasped with it, the attempt to draw out the instrument should not be continued. The blades of the forceps should rather be opened, the bullet set free, and another grasp made; or the instrument should be withdrawn altogether, and a fresh exploration made by the finger with a view to clearing away any tissue that may be lying across the projectile.

Especial care should be taken not to extract a soft foreign body such as a piece of cloth, leather, or linen, from a deep situation roughly or with haste, lest by accident some of the natural soft tissues may have been seized instead of it, or with it. When using traction, notice should be taken whether pain is caused as the traction is made, and whether the substance grasped resists quitting its place of lodgment. In the latter case the operation of extraction should be stopped, and a fresh exploration be made before it is resumed.

One not uncommon impediment in the way of the extraction of leaden missiles when they have become distorted in form, and of all hard irregularly-shaped foreign bodies, is the entanglement or actual interlinking of fibres of cellular and other tissues with the small rugged inequalities of their surfaces and edges. They sometimes seem to act as barbed hooks would, and hold the fibres so tightly that they cannot be disentangled by simple change of position, but must be divided before the separation can be effected. Should an armoured rifle bullet of the present day happen to lodge while retaining its normal form, it would be free from any such hindrance to its removal; but if it had struck a hard substance before entering, so that its metallic cover had been more or less detached from the core, the opposition to its extraction would be especially difficult to overcome. If the finger can reach the projectile, the entangling fibres may often be detached or scraped across by the finger-nail; but if the missile is within convenient reach for the purpose, it is a simpler proceeding to divide them by the edge of a knife.

In the days when spherical bullets were the foreign bodies which had chiefly to be removed from wounds, no attention was necessary as to the direction in which the projectile was to be withdrawn; so long as a hold of it was secured, there was little else to be considered. But with an elongated projectile unaltered in shape, it becomes important that the removal should be effected with its long axis in line with the course of the wound. To grasp a bullet upwards of an inch in length in the contrary direction could only be done by an unjustifiable separation of the blades of the forceps, and stretching of the walls of the contused track forming the wound. If the instrument be one of Coxeter's bullet-extractors, care should be taken that the long axis of the projectile corresponds with the long axis of the scoop. The same care should be exercised by the surgeon in withdrawing slugs, fragments of shell, stones, and all other such unyielding and irregularly-shaped bodies from the bottom of wounds; the walls of which, it is to be remembered, are in a condition highly susceptible to further injury, owing to the severe contusion to which they have previously been subjected.

If the projectile be impacted in bone, in some of the bones of the foot, or in any situation where the fact of the lodgment can be fully established, the depth to which it has sunk into the substance of the bone should be noted, and the means for removing it determined according to its state in this respect. If it be only sticking in a bone superficially placed, after exposing it to view by suitable incisions, it can be readily detached by an elevator. If it be deeply sunk, the elevator cannot be brought to bear suitably upon it, and none of the ordinary bullet-extractors will be of much avail. If a *tirefond* screw be available, it will suffice to effect the desired extraction; but if this instrument cannot be obtained, some thin

layers of the contused bone immediately surrounding the projectile should be gouged away, so that less opposition may be offered by the surrounding bone to its escape. An elevator or common dressing forceps will then generally accomplish the removal. In other cases, as when projectiles are firmly fixed in the shafts of bones, or have sunk to some depth in thin spongy extremities, the only means of removing them will be by the same operative proceedings which a surgeon would have to adopt for the removal of a necrosed sequestrum similarly placed. Such cases, however, will probably be exceedingly rare in the future so far as rifle projectiles are concerned.

Removal of foreign bodies by incision.—In the cases above considered the object has been supposed to be to effect the extraction of the foreign body by the path along which it travelled to its resting-place. But if the lodged bullet or other foreign body cannot be reached by the wound of entrance, but can be felt lodged in the flesh at some part distant from it; or if any circumstances exist contra-indicating its direct extraction, such as its having reached a site beneath structures which there would be risk of injuring, or which would have to be extensively divided in order that the foreign body might be laid hold of; or if, having just stopped short of completely perforating a limb, it is felt lying beneath the skin, or not far from the surface at some point opposite to, or at a distance away from, that where it entered;—in all these and similar cases an incision should be made for its extraction after taking the usual steps to ensure perfect cleanliness of everything employed in the operation. Such counter-openings often have the additional advantage of assisting the cure of the wound by facilitating the escape from it of sloughs and purulent secretions.

The extraction of a lodged bullet by incision may also be advantageous for other reasons. A bullet may be fairly and firmly in the grasp of an extricating instrument, but it may be found that an unjustifiable amount of force would have to be used for effecting its withdrawal. It may be lying so far from the opening through which the instrument has been passed that the finger may not be able to reach it, and the nature of the impediment to its extraction may be unknown, or, at best, only a matter of surmise. When such a difficulty arises, the surgeon will act wisely in not trying to overcome it by excessive force. After various movements have been resorted to with a view to disengaging it from the obstacles which are barring the way to its removal, and have failed, an incision, for reaching the missile by a more direct route, if it be in a favourable position for such means of access, will be a more prudent course to adopt. The following example affords a lesson on the importance of this injunction; for owing to the changed form of the bullet and the situation in which it had become placed,

no efforts for extraction, short of rending asunder the muscular tissues in which it was engaged, could have succeeded in effecting its removal in the particular direction at first tried. In all such cases of difficult extraction, as in those of unsuccessful exploration of gunshot wounds which have been previously adverted to, no absolute rule can be laid down for guidance as to the time when the operative proceedings should cease; the tact and judgment of the operator must be relied upon to decide when the limit of justifiable effort for the extraction of a deeply lodged and firmly grasped foreign body has been attained.

A soldier was wounded in the shoulder in New Zealand in November 1863, and resection of the head of the humerus was performed. The bullet was sought for, but not found. Nine months afterwards, when the patient was in hospital at Netley, search for the ball was again made. A sinus still existed, the orifice of which was on the side of the chest, about two inches below the apex of the axillary space. A probe passed along this sinus took a direction towards the inferior angle of the scapula. Efforts were therefore made in this direction for the discovery of the projectile; and after a time a long probe came in contact with it, lying beneath the scapula on its pectoral aspect, and at a short distance above its inferior angle. A forceps was passed along the track, and a scale of lead was brought away. Afterwards the bullet itself was grasped, and a firm hold got of it, but it could not be drawn away. Several kinds of extractors were employed, but with no success; the bullet appeared to be brought forward for a limited distance, and then to meet with some obstacle which could not be overcome without using an unjustifiable amount of violence. The attempts at withdrawing it by the sinus were now abandoned. An incision was made immediately below the lower angle of the scapula, and then, by passing the finger upward, with a little manipulation the projectile was removed. The difficulty which had been previously experienced was at once explained. The bullet, a rifle projectile, had been greatly altered in form. The front portion was bent at an angle with the base, and was flattened out like an extended wing, being prolonged for nearly three-quarters of an inch from the main part. This thin portion had become fixed between the subscapularis muscle and the bone. The lead surrounding the hollow base of the projectile was marked with the indentations of the forceps by which it had been grasped in the unsuccessful attempts at withdrawing it through the axillary opening. It was now sufficiently evident that it would have been better if these attempts had not been made, and the scapular incision at once adopted when the site of lodgment was discovered; but the bullet having been so firmly grasped by the forceps through the opening already existing, naturally led to the attempts to take it out in that direction. It was fortunate, however,

that the traction on the bullet by the forceps through the existing opening was not persevered with; the bullet could only have been withdrawn in that direction by tearing through the muscle, or by breaking off the flattened portion of the lead and leaving it behind.

Experience has sufficiently shown that it may not be out of place to mention, by way of caution, that the incision for extracting a bullet should not be made hurriedly, without sufficiently exact knowledge that the substance one is about to extract is really the foreign body it is suspected to be. Mistakes on this point have not been unfrequent under the excitement of field practice. An unnecessary incision was erroneously made on the field close to the outer malleolus when General Garibaldi was wounded in the foot by a bullet which entered through the inner malleolus. In the flurry of the moment, either the external malleolus itself, or the elevation of the cuboid near its articulation with the os calcis, was mistaken for the bullet, which was really lodged elsewhere. Surgeon De Lisle of the 14th Regiment has related a case in which the supra-orbital ridge had been fractured, and a portion driven downwards towards the upper eyelid by a projectile. The displaced fragment was mistaken for a bullet, and cut down upon with a view to its extraction, by a medical officer in the trenches before Sebastopol. In each of these cases a more judicious examination would have prevented the error. Dr. Stromeyer has recorded his having seen the outer prominence of the head of the fibula cut down upon under the impression that it was a lodged bullet, in a case where the bullet had already made its exit. This opening had been overlooked. He has also mentioned an instance in which the head of the second metatarsal bone was mistaken for a bullet, and an incision for its extraction made through the sole of the foot. In this case, which terminated fatally, the error was all the more inexcusable, as an examination of the patient's boot would have shown that the projectile which had inflicted the injury on the front of the foot had not succeeded in passing through the leather. Other mistakes of a similar kind might be quoted, some of them not occurring in the field, where the hurried and exciting circumstances among which surgeons are placed may form some excuse for their occasional occurrence, but in places where no apology for such errors can be imagined. Occasionally an incision is made as an exploratory measure, acknowledged doubt existing as to the presence or otherwise of the foreign body sought to be removed; but an experimental search of this kind, when made on sufficient grounds, has no correspondence with the blunders above indicated. They are illustrations of faulty incisions being made for removing supposed projectiles, when the true nature of the parts subjected to the operations might have been determined by proper investigation beforehand; and they are only mentioned to call attention to the necessity for never using the knife without

sufficient circumspection, for careless mistakes of the kind ought not to occur even under the exciting circumstances in which surgeons are sometimes placed in military practice.

When a surgeon, after due examination, finds that the removal by incision is necessary, before using the knife he should fix any such missile as a bullet in its place by pressure upon the soft tissues on either side of it. If it be lying rather deeply among muscles, or under any circumstances where it is not likely to slip away under pressure, this is best done by putting the adjacent superincumbent parts on the stretch with one hand preparatory to dissecting down upon it with the other; but if it be very superficial, the foreign body together with the integument can easily be grasped between the fingers of the surgeon, and held securely while the necessary cut is being made towards it. In some situations it is more convenient for an assistant to grasp the parts below the spot where the bullet is placed, and so to keep it steady, while the surgeon cuts down upon it. Such simple precautions will often cause the extraction of a foreign body to be easily and rapidly effected; when, without them, delay would be caused by the projectile slipping away as soon as pressure is made in its direction. In the instance of a spherical bullet, the incision should be carried beyond the length of its diameter, an addition of half a diameter being usually necessary to admit of its easy extraction; in an elongated bullet the length of the incision must depend upon the aspect of the projectile which is presented towards the surface. The opposite margins of the foreign body should in all cases be fully exposed. Where there is a risk of a bullet being pressed away by the knife in the act of cutting down upon it, especially if it be stuck in the wall of a cavity, as of the chest (a situation where it cannot be prudently fixed in its place of lodgment by the means before mentioned), and still more so if there is reason for believing a communication exists with the interior of the cavity, the incision should be made on one side of the bullet, instead of over it; and when the projectile is exposed, it is better to secure it from slipping away by grasping it with the mouse-toothed forceps, or, if this instrument be not at hand, no attempt should be made to lay hold of it until a scoop or steel director has been carefully insinuated behind the projectile. When once the director is safely behind it, and so maintained, the bullet may be tilted forwards, or grasped by an ordinary forceps, and removed without risk of pushing it into the cavity.

In some parts of the body, after an incision has been made down to a projectile, its extraction may be facilitated by placing the parts among which it is lodged in certain positions, just as it may be rendered difficult by putting them in others. Some attitudes will bring a bullet nearer to the surface than others. Some will cause structures to be tightly stretched across a foreign body;

in others, these same structures will be relaxed or moved aside. The removal of a bullet lodged in the popliteal space will necessarily be found to be a much easier operation in the extended position of the limb than when the knee is flexed. Such circumstances are worth consideration in all cases of deep lodgment, the actions of the various anatomical parts involved being borne in mind. An ingenious application of this precept is afforded in a case related by M. Briot, in which he removed a bullet that had become fixed between two ribs under the right shoulder-blade. The ball had passed through the scapula, and was felt to be solidly wedged between the two ribs. After a free incision, the bullet-opening in the scapula was enlarged. M. Briot then passed behind the bullet the end of a scoop, and, pressing upon it, he ordered the patient to take in a very full breath in order to separate the ribs as much as possible. This movement enabled him to disengage the projectile and effect its extraction.[11]

If efforts have been made for some time without success to extract a foreign body, and the continuance of them is likely to be detrimental, or if from any other cause it has been determined not to make further attempts at immediate extraction, it is best, if inflammation succeeds, to leave the lodged body alone until the first period of it has passed. The removal of deeply lodged foreign bodies is often more easy after suppuration is established. If the foreign body be a comparatively heavy one like a shrapnel bullet with a smooth exterior, it will sometimes change its situation and approach the surface; or it may reveal the exact site of its lodgment by local signs, by pain, or other indications, and its removal may then be effected by some of the means previously described without difficulty. These occurrences may not take place; but the foreign body may prevent the complete closure of the wound, leading to the establishment of a sinus; or irritation may not be kept up by it, but the foreign body may become encysted. Under these conditions the question of extraction becomes one which belongs altogether to a later period of treatment.

There are certain positions in which the lodgment of a projectile entails consequences so dangerous to life, that although its removal cannot be effected by any other means than by operative measures which themselves involve risk to life, yet experience has now sufficiently shown that these operative measures are proper for adoption, or at least justifiable, whenever circumstances admit of their performance. Of the two dangers, the danger of the operation, under the advanced treatment of the present day, is less than that of the continued lodgment of the foreign body. The case of a bullet lodged in one of the pleural cavities, or in the cavity of the peritoneum, affords examples of such positions as I now refer to. The subject is only incidentally alluded to here, for it includes many questions which can only

be properly discussed in works in which wounds of special regions of the body are brought under full consideration.

Occasional cases will occur in which it is desirable to place a patient under the influence of an anæsthetic while examining the nature of his wound and searching for a foreign body in it. There is little doubt that under these circumstances, as in all other cases in which surgical operations have to be performed in the field, of all anæsthetics chloroform, due care and precautions being taken when it is administered, is the most suitable for the purpose. The use of ether is advocated in preference to chloroform by some surgeons. Ether, together with special instruments for its employment, may well be used in fixed hospitals; but in the field its administration generally occupies more time than can be spared without detriment to other patients; and in fact, it is hardly practicable to carry it for field use, on account of its bulk, the quantity which would be required, and the consequent space that would be required for its conveyance. Surgeons in the field should always economise the consumption of chloroform as much as they can. Unless used with great care, the supply, however ample it may appear at first, will be exhausted in case of any large demand before the vacant stores can be renewed, and much avoidable suffering will be the consequence. Dr. Chisolm of South Carolina, where chloroform was a very rare article during the war of the rebellion, invented a chloroform inhaler of such a form that none of the drug, so precious at the time, could be wasted even when administered in the open air. It consisted of a closed metal receptacle for a sponge on which the chloroform was poured. At one end of this case there was a fine wire grating for the passage of air, while at the other end were two short tubes, suitable for being inserted into the patient's nostrils. The vapour of the chloroform was inhaled through the nose, while a proportionate amount of air was admitted by the mouth. One of Dr. Chisolm's inhalers, which he was kind enough to send me, may be seen in the Museum of Military Surgery at Netley. When chloroform is not so scarce, either the ordinary cone of lint or linen, held in the hand and applied over the patient's nostrils and mouth, or one of the portable German inhalers, in which a piece of flannel is stretched on a folding wire frame, forms a safe and ready means of administering the anæsthetic, and is probably safer than any of the more complicated instruments which are sometimes employed for the purpose.

As soon as a projectile, or any other foreign body that may have been detected, is removed, the opening or openings and surrounding skin are to be cleaned, rendered aseptic, and dressed. Perforating wounds by small projectiles are seldom accompanied with much disturbance of the parts adjoining the openings of entrance; but it will sometimes happen, even in simple flesh

wounds, that the soft tissues near the wound of the exit are torn and displaced. Rasing wounds by small projectiles, and wounds over some of the superficial bones, are often accompanied with a good deal of laceration. In such cases, on dressing the wound, attention must be first given to rendering it free from any foreign matters there may be upon it, and as far as possible aseptic, and then to readjusting the disjoined structures in their normal relations to each other. In thus bringing the parts together, the purpose is not only, with the aid of antiseptic dressings, to try and obtain speedy union, as well as to give ease to the patient, but also to prevent avoidable irritation and malposition of parts during the subsequent stages of cure. This readjustment, if carefully done, will give the structures an early tendency to adapt themselves to one another in the same relations in which the surgeon hopes they may be ultimately united. The best method of clearing away clots, and such extraneous substances as dust, fibres of cloth, earth, and grit, from the surfaces of wounds, is by squeezing some antiseptic lotion from a sponge, or by pouring the fluid from an irrigator or other convenient vessel upon them. Such things as small gravel and dust are as often pressed into the exposed tissues as removed from them by the use of tow, sponges, and similar articles, when directly applied to their torn surfaces.

The additional bruising and irritation which would be caused by the incautious use of such substances, and the increased impediments to a favourable healing process, are so obvious as not to require mention. If oozing of blood continues, measures should be adopted to prevent as far as possible its spreading over the adjoining integuments. This can be readily done when the wound first receives attention, but can only be accomplished with considerable inconvenience after the blood has become dry and adherent to the skin, especially after inflammatory action has begun, and the parts involved in the injury have become heated and very sensitive.

The dressings to be applied, and the further treatment of wounds produced by small projectiles, will be considered in the next chapter.

CHAPTER III

LOCAL TREATMENT OF GUNSHOT INJURIES

Moistened lint as a dressing.—In perforating gunshot flesh wounds, as well as in gaping and lacerated wounds from the smaller kinds of projectiles, after the torn and divided tissues had been duly cleansed and brought into proper apposition, the

dressing which was most generally employed by British surgeons in field hospitals, when they were of a sufficiently stationary character for the patients to remain in them for a suitable time, was lint moistened, and kept moist, with plain water at the prevailing temperature of the time. Such moist dressings cannot be conveniently employed in the field itself, either at the regimental line of help or at the regulation dressing-stations, nor would they generally be suitable for use in the movable field hospitals, in which sufficiently close and frequent attention cannot usually be given to particular details of treatment, and where patients are liable to be disturbed by sudden removals. But in hospitals where adequate time and attendance are available, lint kept moist with water has proved itself to possess many advantages as a dressing. It is grateful to the sensations of the patient; the water is easily medicated as required; it is easily renewed; and the lint can generally be got in any required quantity in British field hospitals. Well-made lint, too, has the advantage of being of all substances the softest and most agreeable to sore and inflamed surfaces; it imbibes a large quantity of any fluid in which it is properly steeped; the saturation is easily maintained; and in this moistened condition it yields and readily adapts itself to the shape of any parts of the body to which it may be applied. All kinds of dressing that involve stiffness, pressure, weight, and undue warmth are objectionable.

Poultices of linseed-meal, though they have been used by some surgeons with gunshot wounds, and that, too, within comparatively recent periods, have most of the objections just named in a marked degree. Moreover, to make them well, more time is required than can usually be given in time of war in field hospitals, even in the rear; the materials for their manufacture are not easily transportable, owing to their bulk; they cannot be renewed in war hospitals as frequently as they may be in fixed hospitals in towns; and they soon become rancid, especially in hot climates, and act as irritants in the neighbourhood of the wounds. After a time, too, probably by preventing evaporation owing to their oily constituents, they sodden the parts over which they are placed, lessen their tone, and thus impede a vigorously healthy action. There is, besides, some difficulty in getting rid of them after they have been removed from the wounds, and it requires the close attention of surgeons to prevent them from being thrown away as refuse in some obscure place in the neighbourhood of a hospital where they are not likely to be seen, but where, if they are allowed to remain, they soon begin to attract flies as well as to contaminate the surrounding atmosphere. Linseed-meal poultices ought to be excluded entirely from use in camp hospitals. Ordinary water-dressing is far better, for it is free from the objectionable qualities which have just been enumerated.

In using water-dressing, the lint may be kept moist either by dropping water occasionally upon it from a sponge, a vessel of water being kept at the bedside for the purpose; or, what generally answers better, from a fixed irrigator adapted to the position and other circumstances of the wound. Sometimes the water-dressing is employed covered; the lint, which is usually in several folds, being kept moist by preventing evaporation. Oiled silk, gutta-percha tissue, waxed paper or linen, or an upper cover of lint on which some ointment has been spread, are the materials generally used for the purpose. On consulting a patient's sensations in the selection of either of these modes of dressing, climate and temperature will mostly be found to determine his choice. In hot climates cool evaporating applications are the more grateful, and by lessening the degree of reaction and checking the amount of inflammation, as well as circumscribing its extent, are usually the more advantageous; in cold climates the non-evaporating applications are the more agreeable. But, as a rule, they cannot be long maintained without inducing objectionable conditions similar to those which result from the use of poultices, and then other dressings have to be substituted for them. This was the system of dressing gunshot wounds generally adopted by English surgeons in the Crimean, Indian, New Zealand, and other wars, and under it, on the whole, the results were very favourable. For some years past, however, when water-dressing has been employed, the liquid has been medicated by some of the antiseptic ingredients which are mentioned farther on.

Charpie.—Charpie, or linen separated into short threads about two or three inches long, has been the material in most common use on the Continent, instead of lint as manufactured in England. It has never been in general use among British surgeons, and the absence of it from the regulated dressings of military hospitals has not been regarded as a loss. In consequence of the common use of linen by persons in most Continental countries, even among the poorer classes, all kinds of linen articles, when no longer fit for their original purpose from age, have been converted into charpie, and used in military hospitals in time of war. New linen is considered unfit for charpie, on account of the fibres being too rigid and hard; while half-used linen, having become soft and flexible, is found suitable for the purposes for which charpie is wanted. In the civil Continental hospitals the half-worn-out bed-linen and old articles of personal clothing used generally to be converted into charpie. However clean the linen might seem to be before being pulled asunder for making charpie, it is difficult to believe it could be free from taint from some of the emanations, liquid and gaseous, with which it had probably been long impregnated while in hospital use. Discharges from sores, and the other decomposable substances with which such articles are apt to be soiled,

naturally occur to the recollection in thinking of the origin of charpie thus prepared for surgical purposes. And after it has been collected, cleansed, and stored for use, charpie is so absorbent from its light, fibrous, and porous character, that it must, like charcoal, readily absorb any gaseous emanations among which it may happen to be placed; while, unlike charcoal, it contains no quality which may help to neutralise or correct their deleterious effects. Instances are on record of disastrous effects having followed the use of charpie which had absorbed the germs of specific diseases, and in this way infected the wounds to which it had been applied.

Charpie has one advantage over lint, viz., its superior capacity for absorbing a thick viscous fluid, such as pus. In any wound from which purulent matter is discharged in considerable quantity, charpie may be advantageously employed in conjunction with the lint, not instead of it, as a dressing. But the charpie should be itself strictly pure, and should be impregnated with some reliable antiseptic material. In such a case, the lint being laid on the sore surface, an arrangement is made for the escape of any discharges at one of its edges, where the antiseptic charpie is placed rather loosely to absorb it as it drains away; or the perforated or lattice lint may be employed, and the charpie laid over it and lightly retained in its place, so as to be enabled to absorb the pus as it passes out through the open spaces of the lint. Similar means may be employed in deep hollow wounds when the discharge is profuse in quantity.

Charpie containing a moderate proportion of tar dissolved in a solution of carbolic acid has been specially manufactured in this country, and may be advantageously employed in the way named, owing to its deodorant and antiseptic qualities. Calvert's carbolised charpie has all the characteristic features of simple charpie, but is readily distinguished from it by its brown colour and tarry odour.

Carded oakum as a dressing for gunshot wounds.—During the war of the rebellion in the United States, common picked oakum made from ships' ropes—an old application to wounds among sailors—was introduced as a cheap substitute for lint and charpie, and became extensively used in the field and general hospitals. Picked oakum has since been used in some civil hospitals in Europe, and was reported to be largely employed in the military hospitals in France during the war of 1870–71. The particular advantages possessed by it consisted in the great abundance with which it could be readily and cheaply obtained; in its capacity as an absorbent, owing to the curled and twisted condition of its fibres; in its antiseptic qualities, due to the tar with which it had been imbued; and lastly, in the facility with which, after having been used, it could be got rid of by combustion, owing to the substance last named entering so largely into its composition. Its chief demerit, as it was originally used,

was the coarseness of its fibre, so that it acted as an irritant upon tender and sensitive sore surfaces. To get rid of this inconvenience several finer sorts of oakum, carded by machinery, were introduced as articles of commerce.[12] The more delicate texture of this specially prepared oakum does not appear to interfere with its absorbent power. At the same time, being softer, smoother, and less resilient, it can be applied without inconvenience in case of need to the proximity of inflamed and tender orifices of wounds, or to the neighbourhood of granulating sores.

For most of the hospital purposes to which 'surgeon's tow' has been usually applied—for removing discharges from the neighbourhood of a wound, for making small pillows and pads by enclosing it in bags of suitable texture, for padding splints for cases of fracture after being overlaid by lint or soft linen—well-picked oakum will serve equally well, and probably better, owing to its antiseptic qualities, when the hospital cases under treatment mainly consist of injuries produced by gunshot.

Antiseptic and deodorant applications.—The efficacy of the antiseptic treatment of wounds, as generally understood, has been so abundantly demonstrated, the plan of the treatment itself has been so greatly simplified of late years, and the materials adapted to its application have been so multiplied, that its fitness and advantages for the treatment of gunshot wounds under the various conditions of warfare are no longer subjects of question. The only matters which still remain *sub judice* among military surgeons are not whether antiseptics are to be employed for the treatment of gunshot wounds in time of war, but rather which of the various kinds of antiseptic preparations available for use are the most suitable for military purposes in a campaign.

It has already been noticed that substances possessing more or less antiseptic qualities had been employed for a long time prior to the general acceptance of the principles founded upon the researches of Pasteur, and advocated by Sir J. Lister. The general use for long years of spirits of wine in the various kinds of tinctures in vogue as a topical application to wounds, with the view of counteracting the tendency to putrefactive changes, lessening suppuration, and exciting a healing action; the use of absolute alcohol by many eminent military and civil surgeons with the same objects; a variety of astringent substances applied with the intention of controlling and diminishing wound-discharges; the tow imbued with tar or oakum, so largely used during the great civil war in the United States, are examples of such substances. Others of the same nature formerly in use might also be quoted. During the war of 1870–71 between Germany and France, the permanganate of potash and carbolic acid, especially the latter, were more extensively employed in both the field and

fixed hospitals than they had ever been previously; indeed, under different forms of preparation, or in different degrees of strength, one or other, if not both, may be said to have been universally employed in all the hospitals, both French and German, during the war.

The permanganate of potash, or Condy's solution, has been a good deal used by English surgeons, and has proved itself to be a valuable adjunct to the dressings of gunshot wounds as a deodorant in sores attended by fœtor. It has been found serviceable when highly diluted as an injection for seton-like wounds and in suppurating wounds of much depth. Sufficient for making a very large quantity of solution of suitable strength for use can be carried in a very small space in the crystalline form. But as a germicide and general antiseptic this preparation is neither so energetic or efficient as the carbolic acid, or as another substance which has been much used in the Royal Navy, viz., the chloride of zinc. Moreover, the difficulty of getting rid of the stains which it leaves on bed-linen and other articles when a concentrated solution accidentally comes into contact with them, is another objection to its use in general hospitals.

Carbolic acid, under the name of phenic acid, was employed to a considerable extent after the principal battles of the Italian campaign of 1859, and again during the Mexican campaign, in the French military hospitals. But, as just now mentioned, it was used on a still larger scale than ever in the hospitals of the German and French armies during the prolonged war of 1870–71. The reports by different surgeons of the results of its employment in the field hospitals, both at the time of the war and subsequently, were very contradictory; for some strongly praised its efficiency, while others declared that septicæmia, pyæmia, and typhoid fevers prevailed as much in places where it was used as in others where it was not. But when considering these discrepancies in the views of those who had been actually using the carbolic acid, it must be remembered that few surgeons at the time were personally acquainted with all the qualities of this substance, especially as regards the effects of its use in solutions of different degrees of strength, or were familiar with the minute precautions which were necessary to be taken in its application, according to the teaching and practice of Sir J. Lister, to whose example and influence its employment as a dressing for wounds was chiefly due.

Professor Lister, whose method of employing carbolic acid dressings was based, as is well known, on the germ theory of the production of suppuration and the propagation of disease, published, not long after the Franco-German war commenced, some directions entitled 'A Method of Antiseptic Treatment applicable to Wounded Soldiers.' They appeared in the original edition of this work. The proceedings inculcated in these in-

structions were so complex in their details, and required so much careful attention in their execution, that unfortunately, to any one practically acquainted with the pressing state of things after large battles, it was obvious that the plan described would on almost every occasion of such an event taking place be incapable of execution. Even if the material means could have been found on the spot for carrying out the directions, no army surgeon could have devoted the continuous time for putting them into practice without neglecting other matters of extreme urgency, which on such occasions call for attention on all sides. Subsequently to the period of the Franco-German war, however, the Listerian plan of wound-dressing became greatly simplified; the materials used in it were reduced in number, the carbolic spray was discarded, drainage less resorted to, and, so far as concerned the practicability of carrying out antiseptic treatment in the field by carbolic acid dressings, all the chief technical difficulties were removed. But some objections to its employment for military purposes still remained. The volatility of the carbolic acid caused difficulties in respect to the storage of the materials impregnated with it. It often proved itself to be exceedingly irritating to parts to which it was applied, and occasionally gave rise to symptoms of constitutional poisoning. Thus it gradually lost favour for purposes of general treatment, though its influence in staying the development of micro-organisms of all kinds and arresting putrefactive changes still causes it to be valued for irrigating wounds and certain other special purposes.

Chloride of zinc was at one time largely employed as an antiseptic in the Royal Navy. A solution of it was first used for preserving timber and canvas from the spread of dry-rot and other minute fungi, and afterwards as a general deodorant and antiseptic for flushing the bilges and purifying the air of ships. For many years it was the only substance of the kind permitted to be used on board ships of war, where it was known under the name of 'Sir William Burnett's Disinfecting Fluid.' It thus came to be applied as an antiseptic lotion to gunshot wounds. Inspr.-Genl. Sir William Smart, R.N., published the results of his experience regarding the use of chloride of zinc in gunshot injuries,[13] and wrote very favourably of it. He recommends it to be used in the primary treatment of all gunshot wounds, declaring it to be preferable to carbolic acid or any other antiseptic for hastening the separation of sloughs, and for checking unhealthy action tending to sloughing. He also strongly advocated the application of chloride of zinc to the surfaces of stumps after amputation when exhibiting a tendency to gangrene. The late Mr. De Morgan of the Middlesex Hospital, whose constant practice it was to sponge the surfaces of wounds made by surgical operations with strong solutions of chloride of zinc, also urged its use in preference to other antiseptics in the treatment of gunshot wounds.[14] He

recommended 'a solution of 30 to 40 grains of the chloride in an ounce of water, applied freely in the crevices and dark corners of a wound, sponging it in until the whole surface is creamy, then covering the wound with lint wetted with a solution of five grains to the ounce of water, keeping the covering constantly wetted with the lotion.' The chloride of zinc, being very deliquescent, can only be used for dressing purposes in a state of solution.

The use of salicylic acid in various forms has been strongly advocated by some surgeons as a first dressing for gunshot wounds, from being less irritating to the surfaces of the wounds to which it may be applied and the neighbouring skin than carbolic acid, while possessing all its antiseptic advantages. But in the state of powder it is very irritating to the nostrils of persons whom it reaches, and is only sparingly soluble in water. Professor Esmarch called special attention to its merits [15] as a wound-dressing, and he devised various means for making it applicable to practice in the field. He used salicylised cotton charpie and gauze in his form of soldiers' 'first field dressing.' He advised that all cotton wadding and tow for field use should be salicylised. Dr. Esmarch also prepared small swabs of salicylised jute enclosed in salicylised gauze for wiping blood from wounds, with a view to their being carried in the dressing-cases of hospital attendants, and by bearers of wounded. By using these materials, abstaining from all exploration of wounds at dressing-stations, and by treating the wounds strictly under antiseptic precautions after the patients had arrived in hospital, Dr. Esmarch believed that some of the most severe injuries in war, such as gunshot wounds of bones and joints, might run through a thoroughly aseptic course, and be got to heal almost without suppuration and without fever.

Many other chemical substances have been introduced for use as antiseptic applications in the treatment of wounds. Those which are provided in the field surgical cases by the latest code of regulations for the army medical service, in addition to carbolic acid and chloride of zinc, are the perchloride of mercury, boracic acid, and iodoform. The basement materials charged with antiseptic substances supplied in the field cases consist of lint, gauze, cotton-wool, tow, and tenax. There are also certain contents of the surgical panniers which are entitled antiseptic, such as antiseptic vaseline, antiseptic lint and bandages, but the particular nature of the antiseptic substances by which they have been impregnated is not officially stated.

Of the chemical substances last mentioned, the perchloride of mercury and boracic acid have the advantage of not being volatile in any degree, while the iodoform is slightly so. They vary, however, in their degrees of antiseptic power. The mercuric chloride or corrosive sublimate possesses exceedingly energetic antiseptic properties, and acts upon micro-organisms with great rapidity. It

is very convenient for use in the field, on account of the small bulk it occupies in its crystalline form or in a state of powder, its stable character, the ease with which it is capable of being dissolved, and the small proportion required for constituting effective solutions. It is employed in the dry state in various kinds of dressing, as in sublimate cotton-wool, sublimate lint, and others. It is used in solutions which vary in strength from 1 part in 500 to 1 in 5000 parts of water according to the object in view. It is apt to irritate the skin if it be long exposed to it. It is sometimes used in combination with chloride of ammonium, when it is known by the name of sal alembroth. This compound appears to be less irritating to the skin than the mercuric chloride alone.

The boracic acid has but little power as a disinfectant, and, relatively to other chemical substances, only weak antiseptic action; but it has the advantage of being quite free from irritant effects.

Iodoform is much praised by some surgeons as a topical application to wounds. It is generally used in the form of a crystalline powder, and dusted on and around the wound; it is also used in various kinds of dressings which have been previously charged with it. It is not soluble in wound discharges or in water, and hence its application as a dry powder to wounds. It is only slightly volatile, but it emits a peculiar odour which is very objectionable to many persons, and to some even nauseous. It is said to have produced poisonous effects in certain instances. It is sometimes mixed for use with an equal part of oxide of zinc in order to lessen the liability to toxic results; while a mixture of ground coffee with it is stated to neutralise the unpleasantness of its odour. Iodoform was very extensively used in the field on the occasion of the Egyptian campaign of 1882, and also on the transport vessels in which the wounded were brought to England; but whether from the circumstance of the immediate removal of the wounded and their early subjection to the movements of shipboard, or from defects in the methods of using it, its application did not on that occasion prevent very copious suppuration in a large proportion of the wounds treated by it. In civil practice it has been much used in surgical operations implicating the natural openings of the body—the mouth, nostrils, and anus.

One of the latest substances for antiseptic dressings advocated by Sir J. Lister is the double cyanide of mercury and zinc. It has proved itself to be a most valuable application in the treatment of wounds in civil hospitals, and could be used without any difficulty in the treatment of gunshot wounds in field hospitals. This compound substance is free from the irritating action which in some persons attends the perchloride of mercury; and from the rapidly healing influence which it has been proved to exert in civil practice, not only on recent wounds, whether contused or incised, but also on granulating surfaces, it ought to prove an equally

efficient application in the hands of military surgeons for dressing gunshot wounds.

Of the various antiseptic substances above described, the perchloride of mercury, and the double cyanide of mercury and zinc, if it should be officially supplied, will probably be found to be most generally serviceable for use in the field. The medical and surgical resources in the front during war have almost always been found to be scanty relatively to the demands on occasions of general actions with an enemy; but the facility with which the antiseptic drugs named can be conveyed, and their other qualities, previously described, enable them to furnish within a very limited bulk the means necessary for dressing antiseptically a very large number of wounds. It is well to have other antiseptic materials at hand to meet special needs and the different experiences and predilections of surgeons in matters of treatment; but for general purposes the mercuric perchloride and double cyanide, under the various forms in which they may be employed, will meet every ordinary want as regards antiseptic dressings. Even if it should be true that gauze, cotton-wool, and other such basic substances, when impregnated with these salts, undergo changes after a time at the expense of their antiseptic energy, the salts themselves are so readily reapplied in a state of solution to the dressing materials, that although they may have lost some of their antiseptic power during the time they have been kept in the official stores, the missing strength can be readily restored shortly before the time when they will be required for use. Indeed, with the materials and solutions both at hand, the dressings can be easily rendered efficient, even in the field itself, if it be suspected that they have become antiseptically defective from having been too long in store or from any other cause.

Uncomplicated flesh wounds by rifle projectiles require but little expenditure of time or attention for carrying out antiseptic treatment in its integrity with the materials and dressings previously mentioned. The stringent necessity of commencing the treatment from the earliest available moment has already been remarked upon. If the coverings for wound openings supplied in the soldiers' first field-dressing packet have been turned to proper account in the front, if the antiseptic occlusion of the wounds have been maintained at the dressing-station, and no time has been lost in reaching a field hospital, the continuity of the treatment may be easily assured with ordinary care. Whether a surgeon accepts the doctrine of suppuration being caused by the accession of specific pathogenic microbes, or by the action of certain toxic products or ferments resulting from their presence, or whether he explains the suppurative process in some other way, it is certain that if he undertakes to apply the antiseptic treatment of wounds thoroughly, he must carry it out with the same

minute attention to details as he might be well expected to give to it if he were impressed with a conviction of its absolute truth. It can scarcely happen that the immediate neighbourhood of a wound, although it has been occluded at the first opportunity by antiseptic coverings, will be altogether free from blood, dust, and other impurity on the man's first admission into the field hospital. The margins of the wounds and surrounding parts ought therefore to be carefully cleansed, either by ablution or irrigation, with a sufficiently effective antiseptic solution. There can be no good result from syringing the wound-canal, unless evidence is afforded that fibres of cloth, or some other foreign substances, have become lodged in the track of the projectile; but if the need should occur, it should be done with a moderately warm and weak antiseptic solution with due care and gentleness. With wounds of soft parts by modern small-bore projectiles, any need of the kind can only happen very exceptionally; but with projectiles of other forms, or when rifle projectiles have become deformed before striking the patient, the necessity will be more frequently met with. It appears superfluous to mention the importance of everything that touches the wound being rendered aseptic up to the utmost practicable limit. In first dealing with the wound, and in all subsequent applications of dressings, the prevention of the access of noxious germs, and their consequent development, must be unceasingly kept in view. If the wounded soldier is likely to be removed in a very short time from the field hospital to some other hospital in rear, the dressings which are applied should be carefully secured against displacement, and arranged for not being interfered with for at least several days. No good purpose can be served by a change of dressing unless some particular need for making it presents itself; such as shifting of the existing one, leading to more or less exposure of the wound, pain, escape of discharge, or the occurrence of some other objectionable condition that appears to admit of remedy. It is also important to secure the part in which the wound is situated against local movement as far as practicable. Rest is essential for a steadily progressive repair of wounds. If the patient is in a hospital where he can remain for a lengthened period, much of these precautionary measures will be rendered unnecessary—the treatment will be proceeded with in the ordinary way.

If the wound be an extensively lacerated one, or large and deep, or should it be one which from some cause has been left without adequate protection for several days, such simple cleansing as has just been described will not suffice. In such cases the whole of the torn surfaces of the wound must be disinfected. A strong antiseptic solution must be injected by means of a suitable syringe in such a way as to reach all the parts of the wound. When thoroughly irrigated, all excess of moisture should be gently

pressed away, or removed by absorbent pads, and then the surfaces and edges of the wound should be carefully brought together and maintained in apposition by sutures, by lateral pressure from soft elastic pads, attention to ensure suitable posture, or by any other means that the particular circumstances of each wound may demand. In many wounds of this category, discharges will occur, and exhibit a tendency to become diffused, however strictly antiseptic treatment may be carried out; and in applying the dressings, some provision for drainage will then have to be made. But if drainage tubes are employed, they should be removed at the earliest occasion when they can be dispensed with, for nearly all surgeons now admit that their employment is only admissible when discharges are taking place in such quantity as to render their removal, not merely by absorption in the dressings, but by a determinate channel, a matter of urgency. However carefully prepared and manipulated drainage tubes may be, they are within certain limits open to the same objections as all foreign bodies in wounds, and should only be employed when they are manifestly necessary for ensuring the escape of the secretions of the wound, and thus preventing local fluid accumulations. In selecting drainage tubing, such as has been well proved to be free from irritating qualities should be preferred; the perforations should be large enough and the tubing of sufficient calibre for it to be not readily blocked up; it should be soft and yet sufficiently resisting for the tube not to become closed by such pressure as it is likely to be subjected to by the tissues surrounding it. Tubing which consists of natural caoutchouc is better than that which is made of artificial or vulcanised india-rubber. Decalcified bone tubes have been highly praised by some German surgeons, but have not met with much favour among English surgeons. Strands of catgut, acting by capillary attraction, will answer for drainage purposes in some wounds with narrow tracks. But, as before mentioned, it is only in exceptional cases, in which the healing action has not progressed favourably, and the secretions are in excess, that drainage is rendered necessary; under all other conditions the employment of drainage tubes should be avoided. In any case in which suppuration has happened to occur and is copious, when drainage tubes are not employed, earnest attention should be given to ensure the removal of all impediments to the free escape of the secretions by the wound-openings, so as to prevent the evils attendant on collection and diffusion of purulent matter. With such precautionary measures, and the continued application of the ordinary antiseptic dressings, the discharges will generally become speedily less in quantity, and, provided no foreign substances are lodged in the wound, and no other complication exists, a healing action will quickly ensue. If, however, this should not happen, but from some cause the secretions should continue

profuse, every surgeon who has his patient's interest at heart will not trust to attendants, but will personally assure himself that the evacuation of the discharges is regularly accomplished. If purulent matter, notwithstanding the precautions taken, do not flow away freely, and this appears to be owing to some mechanical obstruction at or near the opening of the wound; or if the outlet appear to be too small in proportion to the dimensions of the cavity to ensure a continuous and sufficient discharge of the pus according as it is formed; or if a collection happen to have taken place and is detected at some point more or less remote from the track of the projectile—then no time should be lost, but the necessary incisions should be at once made for its evacuation. Retained pus is a fertile source of febrile excitement, while, at the same time, it has a tendency to diffuse itself, and thus to widen the area of irritation. An hour's delay in such a case may have a very deleterious influence on the progress and ultimate results of some wounds.

Treatment of inflamed gunshot wounds by irrigation.—At the time of the Danish war of 1864, the attention of military surgeons was particularly called by Professor Esmarch of Kiel to the treatment of gunshot wounds by irrigation, and it subsequently became an ordinary part of their treatment in German military hospitals. The practice of irrigation for lowering high temperature and checking inflammatory action in injured and inflamed parts is of undoubted value; at the same time, in the hands of some surgeons its use has been carried to an unscientific and deleterious extent. The appliance known as 'Esmarch's irrigator' is an ordinary article of the equipment of field hospitals. It consists of a cylindrical metal vessel holding about a quart or more of water. Near the bottom of it a tap is fitted, and connected with this tap is an india-rubber tube about two feet and a half long, terminating in a nozzle with a fine bore. This apparatus can be employed either for the continued irrigation of inflamed parts, for occasionally syringing wounds, or for removing impurities from the parts which surround them. When used for continued irrigation, the vessel itself is placed at a suitable elevation on a shelf, and the tube being properly supported, the water is made to flow upon the wounded part, either in a slight stream, or drop by drop, at the discretion of the surgeon. A trough is provided for carrying off the water into a receptacle by the side of the patient's bed. When used for syringing, the water-can is either held aloft by an attendant, or placed upon some elevated support, while the surgeon directs the stream of antiseptic solution issuing from the nozzle wherever he may deem necessary. If it be directed upon a lacerated wound surface which has been exposed to dirt, or upon a granulating sore, all the parts may be thoroughly cleansed by it in succession without injury. It should be remembered that the higher the vessel is placed, the greater will be the force with which

the stream will issue. Among the equipment of military field hospitals are metal dishes with edges of such different curves that they can be closely applied to any part of a patient's body or limbs, and conveniently employed for catching fluids as they escape from the irrigated surfaces of wounds. When foul wounds have to be dealt with, separate nozzles should be issued to each patient, so that there may be no risk of spreading contamination from one patient's wound to another. In the absence of the regular apparatus for irrigation, extempore means of causing either a continuous or interrupted flow of water, medicated or otherwise, to pass over a wound, may be readily contrived by making use of any vessel which will contain a supply of fluid, and the insertion into it of a flexible india-rubber tube, with a spring wire compressor at the end to regulate the amount of flow, or of a long and narrow piece of lint, each being arranged to act after the manner of a syphon.

Wounds in an atonic condition.—If the healing action in a lacerated wound, especially in a ragged shell wound, should appear to be checked or unduly protracted from any cause—state of health of the patient, deteriorating influences of locality or surroundings, previous habits of life, &c.—if the surfaces should present an asthenic appearance, granulations becoming pale and œdematous, discharge thinner, and all the indications pointing to want of restorative power, occasional syringing the surfaces with lotions combining astringent with antiseptic qualities will often prove to be of much advantage. Lotions of chloride or sulphate of zinc may be employed for the purpose, and may be employed once or twice daily. After the application of the lotions, a slightly moistened gauze pad may be laid on the wound, without any intervening protective material, and over this an abundant covering of some dry antiseptic gauze—the double cyanide gauze being preferable according to my experience—secured by an antiseptic gauze bandage. This bandage should be rather strongly applied, that is, sufficiently to exert a general elastic compression of the parts implicated in the wound. The purpose is to brace and excite a more vigorous action in the wounded surfaces and their immediate vicinity. At the same time efforts should be made to discover the cause of the defective healing process, with a view to mitigate or remove it if detected. Under all circumstances, the local applications, to be thoroughly effective, must be accompanied by the administration of iron in a convenient form, or other appropriate constitutional remedies, and by a sufficiently supporting dietary.

Great cleanliness necessary in treating gunshot wounds.—Under all circumstances in the field, the strictest attention to cleanliness in its most extended sense—not merely in all that concerns the manipulation of wounds, but also in the regular

and complete removal of stale dressings, soiled linen, unclean bedding, and of all other sources of infection, in the free aëration of tents and huts, as well as of the wards of stationary hospitals, so that as pure an atmosphere as can be obtained may be constantly preserved—is essentially necessary, both for the general comfort and constitutional well-being of patients with gunshot wounds, as well as to allow the process of repair in their wounds to go on healthily and without interruption. It cannot reasonably be expected, without minute attention to these hygienic requisites, that the ill effects will be averted which result from the dissemination of noxious effluvia in places where patients with sloughing and suppurating wounds—as many shell and other contused and lacerated wounds will certainly be after great battles—are gathered together. Without strict purity in the surroundings of a wounded patient, no less than in all that belongs to the patient himself, no amount of antiseptic dressing can be relied upon for maintaining healthy progress in the healing of his wound, especially in the field, where so many sources of contamination abound. This subject will be again considered when the constitutional treatment of wounded patients is discussed.

Extreme cleanliness is also essential in camp hospitals for protecting the patients against that troublesome source of irritation which has been elsewhere noticed, viz., the plague of flies. It is also important from another point of view that careful attention should be paid to the removal of all that attracts flies, and to the means of obviating their access to wounds. The extent to which such insects act as carriers and communicators of infection is but very partially known. All the more, therefore, when there are wounds from which sloughs are being thrown off, especially if at the time there are any cases of erysipelas or purulent infection near at hand, should the most complete precautions be taken to ward off flies from the neighbourhood of wounded patients.

Treatment of gunshot wounds by hermetically sealing their orifices.—A 'method of rapidly healing gunshot wounds' was brought to notice during the United States civil war by Dr. Chisolm[16] of the Confederate States army. It was on the same principle that Dr. Howard of the Federal army advocated the treatment of penetrating gunshot wounds of the chest by hermetically sealing up the aperture or apertures made by the projectile in its walls, and so excluding the passage of atmospheric air through these openings. In a similar way Dr. Chisolm shut up the track of a bullet through the muscular coverings of the trunk of the body, or one through a limb, even though a bone or bones might be shattered. He called it 'converting gunshot wounds into subcutaneous injuries.' His description of the process was the following: 'Immediately after the injury has been received, when all foreign bodies have been removed, including fragments of bone,

and when hæmorrhage has been checked, but long before any reaction has been established, make two elliptical incisions, extending only through the thickness of the skin, and enclosing the wound with its immediate surroundings of crushed tissues. Dissect up this elliptical flap of skin from the muscles, and two clean incisions are substituted for the ragged wound. If these incisions are carefully brought together by sutures, and the limb or trunk be supported by a roll of bandage, they will rapidly unite by the first intention; converting the track, however long it may be, into a subcutaneous wound, which will heal rapidly without suppuration, by a remodelling process, which is well exemplified in the subcutaneous division of tendons.'

Dr. Chisolm anticipated the most important results from this mode of practice, not only in the rapid healing of the wounds, but also in the escape of patients from secondary hæmorrhage and other complications.

The objection that the skin was not likely to unite over an excavated track was answered by reference to the healing of an incision which had been made for cutting out a lodged bullet or fragment of shell. A second objection, that the tracks of some wounds are lined with crushed tissues which will slough, was thus answered—if the air be completely excluded, these tissues will disappear by absorption, just as suppuration and sloughing do not ensue, but the crushed tissues disappear, when small tumours are torn up subcutaneously. The surgeons in the field with the armies of the Confederate States were requested to test the efficacy of this practice, but the results were not published, so far as I am aware. A copy of Dr. Chisolm's remarks was forwarded by the late Sir William Muir, when Director-General, to the principal medical officer in New Zealand during the last war in that country, in order to give the surgeons engaged in active operations in the field an opportunity to test the practice, if they found no objection to making the trial. It was tried by Staff-Surgeon, afterwards Sir A. D. Home, V.C., and the result, so far as that officer's experience went, was decidedly unfavourable to it.

Dr. Howard's treatment by hermetically sealing, so far as chest wounds were concerned, was very fully tried during the war of the rebellion in the United States. Many cases treated by it are described in detail in the official surgical history of the war. The general conclusion given regarding it is that the indiscriminate application of it was found to be pernicious. (See the History, Part I., pp. 417–514.) The distinguished army surgeon Dr. Billings has stated that, from his observation of the practice, although the occlusion of the chest wounds by its means sometimes gave marked relief to the dyspnœa, the relief ceased when the process of suppuration, which the mode of treatment did not prevent, set in. He added that 'the part of the process

which consists in paring the edges of the wounds, merely inflicts useless pain on the patients.' [17]

Treatment by pneumatic occlusion.—Another method of attaining one of the principal objects of the hermetically sealing process, viz., the protection of the surfaces of a wound, such as a shell wound, from contact with the external air, is the plan of treatment by pneumatic occlusion, introduced by Dr. Jules Guérin,[18] and employed during the siege of Paris. It consists in applying, over the part where the wound is situated, an india-rubber bag, the edges of which are so adapted to the surfaces around the wound that no air can enter the bag. The bag is connected by a tube with a glass globe, which is converted into an exhausted receiver by connection with an air-pump. Whatever discharges there may be from the wound flow along the tube into the globe without contact with air. Arrangements are made for their removal from the glass receiver without the admission of air, and, by reversing the action of the pump, lotions may be applied to the dressings over the wounds without removing the india-rubber envelope. Even if this method of treatment should be attended by any special advantages in fixed hospitals, it is manifestly too elaborate for use in field hospitals. Dr. Gordon, who was commissioned to report on surgical matters during the siege of Paris, stated it was successfully carried out by Dr. Guérin during the siege; but it is evident that, under the usual conditions of besieged places, so complicated a system of treatment could not be generally resorted to. The simplest applications, and those that require the least time, are all that surgeons can practically use under the peculiar circumstances of military duty in time of war; and if only the difficulties of meeting hygienic necessities can be overcome, such applications will generally prove most conducive to the comfort and best interests of the patients.

Treatment by cotton-wool coverings.—Surgeon C. J. F. S. Macdowell of the 3rd Bombay Light Cavalry, who served as a medical volunteer with some of the French troops during the siege of Paris, published a pamphlet [19] in which he strongly praised a method of treating gunshot wounds by Dr. Gruby, from which he witnessed some remarkable results. Dr. Gruby served at the Italian Ambulance in Paris.

His practice was to place pellets of cotton-wool saturated with some antiseptic oil on the wounded surfaces, to place a thick pad of cotton over the pellets, and then a bandage over all. Dr. Macdowell stated that in all the wounds he saw dressed by this method, the secretion of pus was very small in quantity; and that even on holding a 24-hours' dressing close to the nostrils, there was no offensive odour whatever. The patients told him they had never suffered any pain from first to last. Dr. Macdowell remarked that not a single instance of pyæmia or gangrene, which

was rife in some hospitals during the siege, occurred among Dr. Gruby's cases; and he threw out the suggestion that this would be a good treatment to adopt for jagged and contused wounds in India, where cotton is so abundant and cheap, and where grain oils are so inexpensive.

Some surgeons, especially M. Alphonse Guérin, have strongly advocated the use of a thick covering of cotton-wool, or cotton wadding (*pausement onaté*), as a means of filtering the air and preventing the access of noxious germs, and of decomposing particles that may happen to be in it. When skilfully and securely applied in sufficient quantity, this cotton-wool dressing acts not only as a soft but also firm support of the parts over which it is placed, so that a patient may be removed in a jolting vehicle without displacement of the injured structures and without pain. I have seen a patient with a recent fracture of the femur under M. Guérin's care in the Hôtel Dieu, Paris, have the injured limbs raised by M. Guérin, and then let fall on the bed, without any pain or apparent inconvenience. The dressing in this case was as large as an ordinary bed pillow, and was firmly bandaged. Such bulk would alone render this mode of dressing unfit for field service. There can be no doubt, however, that cotton wadding, especially some of the well-prepared kinds of antiseptic wool, forms a valuable addition, even in a moderate quantity, over the dressings of many gunshot wounds, as a protection against injury during transport, and in all cases in which it is important to maintain an equable temperature. Its quality as a bad conductor of heat may then be turned to useful account, while its softness and lightness allow it to be applied over parts which are very tender and sensitive with less inconvenience, perhaps, than any other substance.

Prevention of muscular contractions and stiffness of joints during the healing of wounds.—I have elsewhere mentioned that no inconsiderable proportion of the soldiers who have hitherto been compelled to be discharged from service in the army on account of the remote effects of gunshot wounds, have been disabled by contractions. In all suppurating gunshot wounds, and especially in those which remain a long time under treatment, great care should be taken that the positions of the injured parts are changed from time to time during the process of healing, and that properly regulated passive motion forms part of the subsequent treatment. Sufficient notice hardly appears to have been formerly directed to these points. Surgeon-Major Matthew, who was in charge of the Surgical Division of the Invalid Hospital at Chatham for a considerable part of the time when the men who had been disabled by wounds received in the Crimea were in progress of being discharged from the service, wrote in a professional report at that period: 'The contractions following wounds, from

the great amount of suffering entailed upon the patients, the length of time usually necessary for their successful treatment, and the number of men lost to the service from this kind of disability, to say nothing of the tax on the time, ingenuity, patience, and resources of the surgeon in carrying out such treatment even to a moderately successful issue, seem in my opinion to justify me in attaching a very high importance to the preventive treatment of injuries likely to be followed by contractions. It may be safely asserted, were due precautions as to position in the more acute stages of inflammation, early passive motion of the affected parts, and judicious exercise, enforced by the surgeon, that a very large proportion of cases of contraction, both after accidental injuries and gunshot wounds, which are now sent here, would never need admission into this hospital. There can be no question but that it is often very difficult and sometimes impossible to carry out such a line of treatment, as the co-operation of the patient cannot always be obtained; but in my own practice in the treatment of gunshot injuries I have usually found little difficulty in preventing a limb from becoming fixed in a set position by applying a splint one day and leaving it off the next, and by insisting on, and seeing applied, the use of passive motion.'

It seems probable that serious contractions were far more frequent sequelæ of gunshot wounds in former days than they have been of late years, and still more so than they are likely to be in the future. The greater proportionate numbers of suppurating wounds, and the length of time they were under treatment in those days, afford a sufficient explanation for their frequency. During the Peninsular wars, and after the battle of Waterloo, there were certain wards in the Invalid Hospital at Chatham designated and set apart as 'Contraction Wards.' Though the number of wounded men invalided for contractions may not be so large in the present day, they are still, however, sufficiently numerous to make the matter one of importance enough to call the attention of surgeons to it.

It too often happens after a wound has been dressed that the supports and pillows are arranged, and the limb replaced in position, exactly as they were before the dressing was commenced; and that this system is followed, day after day, until the patient is able to leave his bed. Being accustomed to one position, he fears to have it altered; and at last, as the healing process goes on, as adhesions in parts adjoining the seat of injury become formed, and as all the structures gradually adapt themselves to the special relations established between them in the maintained posture of the part of the body concerned, any change will necessarily entail more and more pain and inconvenience in proportion to the length of time the wound has been under treatment. It is therefore as important to commence changes of posture early in the treatment, as it is to continue them

throughout its course. When the healing process is complete, and continuity has been restored after a deeply penetrating wound, even under the most favourable plans of treatment, there will probably remain some amount of stiffness, some impairment in power of action of the wounded structures; but this amount will be materially diminished if judicious preventive measures have been systematically pursued during the treatment of the case.

Great attention has been given on the Continent to the use of mineral waters from natural hot springs in the treatment of contractions, painful and restricted muscular movements, stiffness of joints, and lameness, consequent on gunshot wounds; and in some countries military invalids suffering from such results of gunshot injuries are officially sent to special establishments where such thermal waters exist. Although not the custom in this country, a certain number of military invalids suffering from similar ailments were sent to Bath for treatment after the Crimean war. The qualities of particular thermal springs, and their respective efficacy in the cure of the various disabilities which occasionally follow gunshot injuries, have been subjects of much observation and study abroad. Contractions due to adhesions, cicatrices of wounds, together with atrophic changes and loss of muscular power, feeble circulation and œdema after gunshot fractures, sluggish separation of sequestra, partial anchylosis after gunshot injuries and wounds of joints, have been the affections especially subjected to treatment and study in thermal institutions. The natural sulphur springs seem to have been found the most serviceable in the treatment of the surgical conditions just mentioned. The waters are used in the forms of general or local baths, of douches so arranged that the nature and force of the stream directed against the affected parts can be regulated according to particular local conditions, and are sometimes given internally. At the same time systematic massage is applied to the parts involved in the contractions and adhesions, or in the deteriorated muscular movements. By these means, in suitable cases, and when skilfully directed, the records show that numerous invalids have been greatly relieved, while in many instances a cure has been effected, and active use of the affected parts has been restored. In cases where the usual treatment in ordinary military hospitals has been prolonged, and attended with imperfect or unsuccessful results, the stimulating effects of the thermal treatment systematically carried out may well be expected to produce beneficial effects; but in such cases part of the benefits conferred may well be attributed to the change of air and scene, and the escape from the hospital atmosphere and surroundings, or from the sick rooms in private houses, to which the invalids have been previously, often for considerable periods, accustomed.

CHAPTER IV

TREATMENT OF INJURIES FROM LARGE PROJECTILES OR THEIR FRAGMENTS

Contusions produced by heavy projectiles.—The treatment of injuries produced by the heavier kinds of projectiles—fragments of shell, grape-shot, and others—may now be considered. It may be taken for granted that injuries from solid gunshot, or shells before explosion, so common in the Crimean and some later wars, will be seldom met with in future conflicts. Solid shot have almost entirely disappeared from field service, and among the changes which have taken place of late years in hollow shells; the introduction of more violent explosives for bursting charges may be expected to lead to a more thorough disruption of the metal exterior. Thus injuries caused by shell fragments of less size and weight, but armed with far higher rates of velocity, may be expected to take the place in a majority of instances of the injuries caused by the more massive missiles which were not unfrequently witnessed in former days.

Before speaking of the open wounds which the larger masses of metal were accustomed to cause, and may still occasionally give rise to, it will be well to mention the treatment which seems best fitted for the injuries which occasionally result from their impact without any open wound having been produced; especially for those which have been previously referred to as 'contusions from the brush of a shot,' and those which have sometimes been erroneously attributed to the 'wind of a ball.'

Contusions produced by heavy shot and fragments of shells, when these projectiles have struck a part of the trunk, even though they may not have been accompanied with obvious injury to viscera, or when they have struck a limb, although they may not have inflicted mischief enough to make the removal of the damaged extremity afford the best chance of safety for the patient, are always of sufficiently serious a nature to excite much apprehension respecting their probable consequences.

In occasional instances heavy masses of metal, especially when they present smooth surfaces and strike glancingly, produce contusions the extent and complications of which it is by no means easy even for experienced military surgeons to estimate. Hence there is sometimes an absence of proper treatment at the outset, and lamentable consequences ensue. In some instances the amount of swelling and rigidity due to the quantity of effused blood acts as an impediment to a correct knowledge of the condition of the deeply seated tissues. In other instances there will

be so little mischief apparent to the sight or touch, that a surgeon will be thrown off his guard and not enjoin the necessary care and quiet with sufficient earnestness. The patient, too, will occasionally make light of his injury, from the absence of any marked indications of its severe character; or he may do so from hardihood, or from being reckless of consequences, and refuse to subject himself to the restrictions and treatment which are really necessary. Thus from some of these causes, singly or combined, the injury becomes neglected at the early period of its occurrence, the time when proper care would have been of most avail. The patient forces himself to remain at his ordinary duty, taking his usual exercise in spite of increasing pain and difficulty, until he is no longer able to move about. Absorption of the effused blood in the damaged parts does not take place, recovery of the injured tissues is prevented, and the final result is that inflammation ending in abscess is excited, or perhaps sloughing follows in some of the deep tissues, eventually disabling the patient altogether for military avocations.

Contusions from missiles of moderate weight.—Slight contusions from fragments of shell of moderate size and weight, or from fragments the chief part of whose force has been expended, cause ecchymosis, but seldom give rise to the necessity for any special treatment beyond taking steps to ensure complete rest in a suitable position of the injured parts, and protection by cotton-wool covering, with proper support from retentive bandaging. If there be any considerable pain on muscular action, it generally forces the patient to rest the contused part as much as possible, the ecchymosis by degrees disappears, and restoration to a sound state gradually ensues. It is not to be forgotten, however, that exceptions will occasionally occur as regards immunity from ill results, even in these apparently slight forms of contusion. If any considerable quantity of blood is effused, inflammation will sometimes follow, and go on to suppuration and the formation of abscess; or the effect of the contusion may be concentrated on important blood-vessels, compromising the arterial flow, or on some nerve, leading, if neglected or further irritated, to persistent pain, or even to more or less complete paralysis of the parts to which it is distributed; the surface of a bone may be involved, and circumscribed periostitis originated; or, especially if the ribs and sternum are concerned, caries or necrosis may ensue. In many such cases early care and rest would suffice to avert all such untoward consequences. Contusions, slight in appearance, of the head from projectiles are often the sources of much trouble in military practice. Not unfrequently, although not producing any of the more obvious morbid conditions which occasionally result from these injuries, seemingly slight shell contusions lead to symptoms which cause soldiers eventually to

be discharged from the army; and there is reason to think that, occasionally at least, these results are in some degree to be accounted for by want of sufficient care in the early periods of the injuries, owing to the absence at first of any very manifest indications of their real gravity. The soldier regarding the blow which he has received on the head as a matter of trifling moment, and trusting that the heaviness and headache he experiences after it will pass away of its own accord, pursues his usual habits, exposes himself to the sun, perhaps indulges to excess in stimulants. Thus the local mischief, or perhaps inflammatory action, which under other circumstances would be resolved, is kept up, and slowly but surely induces progressive morbid changes which become in the end too firmly established to admit of removal.

The chief indications in the treatment of all gunshot contusions which are moderate in degree and extent are immediate prevention of movement of the injured parts; the application of cold to limit effusion of blood, and to counteract tendency to inflammatory action; avoidance of local weight and pressure; the maintenance of an easy position of the part injured, and complete repose, so long as any tenderness continues. When the seat of contusion is near to important viscera, careful attention must be given to prevent excitement and disturbance of the organs in proximity to the seat of injury.

In accordance with these indications, the use of ice, when it can be obtained, will sometimes prove beneficial, but must not be used when the superficial tissues appear to be seriously injured, lest it lower their vitality so far as to induce mortification. In the absence of ice, evaporating water and spirit dressing, cold irrigation, the subacetate of lead lotion, or any other such cooling and discutient applications, may be employed with advantage. Moderate friction and stimulating applications, carefully employed, will often be serviceable for promoting absorption of the effused fluids, and for restoring tone to the injured and weakened structures in the later stages of the milder forms of such contusions.

Contusions of the walls of the abdomen from shell fragments and other such projectiles, however trivial they may at first seem to be, should always receive careful treatment. Although no visceral complication, and nothing more than a slight effusion of blood in the abdominal wall, may be exhibited, peritoneal inflammation or parietal abscess is easily excited when insufficient precautions are taken to avert these accidents. It should not be forgotten, too, that there is frequently met with, after these injuries, a tendency to circumscribed muscular atrophy, and, as a further consequence, to ventral hernia. Rest in the recumbent position, keeping the abdominal parietes in a relaxed condition by flexing the thighs on the abdomen, appropriate local applications

for moderating inflammation, so long as any pain or tenderness continue at the seat of contusion, together with artificial support of the injured abdominal wall when the patient is allowed to rise and take exercise, are prominent features of the treatment called for in these cases.

Contusions from more massive projectiles.—When a large mass of shell has struck a fleshy part of the body with its convex aspect, or when any kind of heavy shot has come into collision with the surface very obliquely and has failed to make an open wound, one of two kinds of contusion are usually presented to the surgeon. In the one, the severe pounding or compression to which the structures opposed to the projectile have been subjected, are manifest to the sight from the surrounding ecchymosis, swelling from effusion of blood, coldness, and loss of sensation, of the part injured; in the other, superficial evidences of the damage which has been done are wanting, but though the integuments seem to have escaped, the symptoms point to the worst effects of the contusion being deeply localised. The situation of the part of the body impinged on may determine these differences, or it may be the difference of direction with which the projectile has struck, as elsewhere explained when considering internal injuries without external marks. But certain parts of the body are more favourable for the occurrence of each of these kinds of contusion than other parts. Where bony structures are only superficially covered with soft tissues the superficial parts concerned are more likely to present abundant evidence of the severe injury to which they have been subjected; in the parts where thick layers of muscular tissues overlie the solid structures—in the nates, for example, the fleshy part of the thigh, or the calf of the leg—the form of contusion in which little superficial mischief is exhibited, while serious crushing exists below, is generally met with. It is to these latter cases that the surgeon's attention requires to be more particularly given, for it is easy to be deceived as regards the extent and gravity of the damage done in the deep tissues when the inspection of the injured part is hastily or carelessly made.

The great object in all cases of severe contusion must be to maintain the integuments intact, so as to prevent the access of air to the damaged tissues beneath, and to keep the effects of the mischief within the bounds marked by the projectile. Care and proper treatment may accomplish this in cases in which the vitality of the skin is only partially compromised; while in the same cases rough and injudicious treatment may readily cause the integument to give way, and mortification to extend to parts beyond the immediate seat of injury. The chief source of danger after such contusions, excluding those cases which are complicated with visceral complications, is the tendency to the formation of deeply seated abscesses. The abscesses may result from inflammatory

changes in the injured tissues occurring shortly after the injury, or may occur later, slowly taking the place of effused blood. If blood have been extravasated so as to form a defined tumour, efforts should be made to obtain its removal by absorption ; it should not be opened if the operation can be avoided. The admission of air will only lead to suppuration, and if the surrounding tissues be much contused, may lead to gangrene. But if a large quantity of blood has been effused, and the swelling resulting from it remains undiminished in size after two or three weeks have elapsed, despite all attempts to obtain resolution of it, it may be treated as an abscess, and evacuated under antiseptic precautions in the same way as if it were a depôt of pus. If allowed to remain untouched indefinitely, it will in all probability excite surrounding inflammation, pain, constitutional irritation, and lead to the formation of pus. An extended abscess will then result, in which clots of blood will be mixed with the purulent contents. The attempt may be made to evacuate the collection of blood by a trocar and canula, taking care to arrange the skin so that the opening in it may not correspond with the opening in the fascia after the withdrawal of the instrument, or by aspiration, and thus to obviate, as far as possible, the admission of air into the space from which the blood has been extracted. If the blood be sufficiently fluid to flow away, as soon as the tumour is emptied an antiseptic compress and bandage should be applied, so as to maintain a moderate but equable pressure over the part. Sometimes these efforts will not succeed, and inflammation and suppuration will follow ; a free incision should then be made, the seat of the abscess disinfected, and the usual antiseptic dressings applied. It may be expected that healing of the injured parts will then gradually follow.

In a certain proportion of such contusions, parts beneath the surface which have received the concentrated impulse of the heavy blow are so crushed that their vitality is practically destroyed, and their loss by sloughing an almost inevitable result. The surrounding structures are also more or less strained, the degree of injury lessening as the distance from the centre of impact increases. Although the integument may remain entire, its vitality must be more or less weakened ; but no effort should be spared to preserve and restore it to its normal condition. If the damage it has sustained seems to be beyond repair, indicated by undue coldness to the touch and loss of natural sensibility, the death of a portion of the integument may be feared to be inevitable. If this should occur, the surgeon's duty then becomes to assist nature in the process of detaching the mortified tissues by appropriate local applications. At the same time earnest attention should be given to warding off all septic influences and sources of irritation from the less severely injured tissues immediately surrounding the principal site of injury. Antiseptic treatment

should be strictly pursued, and the surroundings of the patient maintained in as hygienic a condition as possible. The strength of the wounded man must be supported, that the process of separation of sloughs may proceed vigorously and steadily. Not only the present advantages are greater when the healing process advances regularly and healthily, but the risk is less of future sources of disability after the healing is accomplished. Rest, suitable antiseptic dressings, the maintenance of an equable warmth around the seat of injury, the removal of all undue pressure or constriction, and, when necessary, the administration of sedatives to allay pain and procure sleep, are the points chiefly to be insisted upon. In the field, the removal to long distances of patients suffering from these injuries, and their transportation in rough and jolting vehicles, should be obviated as far as circumstances render it practicable to do so. Opium in some form is the most valuable sedative medicine for allaying pain, and preventing the constitutional irritation and exhaustion it would otherwise excite. The diet should be as simple and readily digestible as can be procured. Everything tending to weaken and depress the patient should be avoided, in order to maintain his bodily powers for the ordeal he will have to go through. As the sloughs separate, offensive odours and discharges must be neutralised by the usual means; and at this time especially some of the tonic medicines—quinine, the mineral acids, and others, the addition of wine or other stimulants to the diet—will be most serviceable. If the contusion be one seriously involving a considerable part of one of the extremities, the question of amputation will have to be considered, and the practice to be followed will be determined by the nature of the structures involved, the extent of the injury, the constitutional condition of the patient, and other special circumstances. It is not to be forgotten that in some cases, when the integuments have remained entire, such a degree of firmness of the damaged portion of the limb has been met with, from the distension of the subjacent tissues by the blood poured out among them, that even the existence of comminuted fracture of a bone has at first been overlooked; and that in all cases, under such circumstances, the exact amount of destructive crushing effected is likely to be very materially masked. The accompanying symptoms will rarely, however, leave a surgeon in doubt as to the extreme gravity of the case when it is really one in which the performance of amputation is called for.

Open wounds from shell fragments and heavy projectiles.—As the wounds inflicted by the fragments of shells projected from field guns are greatly modified in their nature and characters by the number and sizes of the fragments into which the shells are burst, the distance of the wounded men from the focus of explosion, and the parts of the body or extremity wounded, so

also will their treatment and its results vary. This has always been the rule; but the fact will probably be forced on the attention of surgeons more than ever in the future, if the shells used are made of cast-steel, and high explosives form the bursting ingredients, as seems likely to be the case in some armies, not only when they are fired against troops behind shelter, but also in the open field. The fragments will be more numerous, and therefore generally of smaller dimensions, than they were with shells of the old kinds. Some of the smaller fragments with very sharp edges, when they happen to strike tangentially, will inflict wounds which approach in their nature to incised wounds; some small fragments will penetrate and become lodged at a depth determined by their velocity at the time of striking; other larger fragments will give rise to the varieties of jagged and contused furrows and excavations which such missiles have hitherto habitually produced. The vast gaps and ablations which were caused by the solid gun-shot used in the field in former battles may occasionally, though rarely, occur from shells striking the body before explosion, and now and then from the great size of one or other of the fragments after explosion. Surgeons will have little to do with these injuries in the way of treatment. If the body be struck, death must be almost instantaneous from the destruction of organs essential to life; and if it be one of the extremities which has received the impact, either the part of the limb struck will be totally removed, or so crushed that amputation of the damaged parts, if the patient do not succumb to the shock of the injury, will be the only remaining resource.

The treatment of wounds caused by sharp-edged fragments of limited size which have struck a part tangentially needs no special remark. Even when they may happen to be of considerable length, and of some depth, ordinary antiseptic occlusion and treatment, with the usual precautions against local disturbance and movement, will suffice for their speedy cure. Wounds in which angular fragments have penetrated deeply may be expected to lead to more troublesome consequences. As the fragments by which such wounds are caused generally have very sharp and irregular outlines, with rugged surfaces, their tracks are torn, contused, with disintegrated particles pressed into them, and not unfrequently complicated by the presence of pieces of unclean clothing which the missile has carried before it. Under such a condition of things, however strictly antiseptic treatment is applied, suppuration is almost unavoidable, and unless all foreign substances are removed, is likely to persist for a long period. All reasonable efforts, therefore, should be made to extract shell fragments early, even when the size of the opening through which such a fragment has passed shows it to be a comparatively small one. Still more is this necessary when the lodged fragment is

large. In such a wound the contused sides of the hollow track left by the missile are deprived in a great degree of their natural tone and elasticity, while very probably the fragment of shell is covering a quantity of broken-up tissue which it has forced before it. It is obviously necessary that the wound should be relieved as soon as practicable of all such sources of irritation, whether the missile itself or other foreign substances which may have accompanied it, in order that the healing process may proceed satisfactorily. Yet, as shown elsewhere in this work, such impediments to healing action have on many occasions been at first overlooked, and have only been detected and removed after considerable delay and much suffering to patients.

In all uncomplicated flesh wounds of the kind just described, the general principle of treatment should be a careful exploration of the wound, antiseptically conducted, at the earliest suitable opportunity in a field hospital. If a piece of shell is found lying at the bottom of the wound, it should be extracted cautiously, to guard against additional laceration of the tissues during its removal. As soon as the fragment has been removed, and any pieces of cloth, detached tissue, or clot gently cleared away, the entire wound should be disinfected by the use of an antiseptic lotion of sufficient strength, and the surrounding surfaces cleansed. If the wound be of moderate size and suitably situated, dry antiseptic and absorbent dressings may now be applied, the sides of the wound should be efficiently sustained, and if it be in one of the extremities, the section of the limb in which it is situated should be immobilised by the most appropriate means available. All undue pressure and constriction should be carefully avoided in the application of these supports; their purpose is simply to relieve the bruised and weakened tissues of the strain which would otherwise result from their own weight, and to ensure their complete rest and protection.

When a fragment of shell has penetrated for any considerable distance superficially beneath the integuments, so as to have caused a bag-like wound without an exit opening, in which sloughs may remain pent up, or pus not readily escape even with the aid of drainage tubes, a free incision of the surface, so as to lay the whole of the contused wound open to view, is generally advisable. Any foreign substances contained in it can be at once removed, its whole surface more thoroughly disinfected, and the necessary dressings more directly applied. The healing process will be thus facilitated.

If a quantity of the soft parts have been torn up, forming a partially detached flap, it should be carefully replaced in its normal relations after disinfection. However dark and injured such a flap may appear to be, there is always the hope that much of it may retain its vitality; and in like manner, when other parts have

been torn from their natural connections, they should be carefully restored to their former situations, no part being cut away which is not so completely crushed as to be deprived of all vitality. A few sutures may be employed if absolutely necessary to keep the parts together; but it is much better to abstain from using them on such occasions, if an arrangement of posture, simple dressings, or any other means can be relied upon for keeping the lacerated and more or less bruised tissues properly approximated to each other. If the wounded man has been removed to some hospital, where he can remain quietly after his wound has been dressed, the usual dressings and sustaining bandages, but, above all, appropriate position of the limb or part of the body in which the wound is situated, will generally answer the object aimed at. Rest, as complete as practicable, of the wounded part of the body must be maintained in order to prevent irritation of the injured structures. When portions of the wounded structures have been profoundly damaged, as the sloughs are thrown off—and there will always be a certain amount of tissues so far deprived of their vitality in grave wounds caused by heavy projectiles that they will have to be separated from the less severely crushed parts in the process of cure—the wound must be treated as a case of local traumatic gangrene. The surgeon must be on his guard against the various complications, particularly against septic poisoning, which may readily occur in such cases. The support and maintenance of strength, and the relief from pain by appropriate remedies—points elsewhere dwelt upon—are of the greatest importance in these injuries, which are generally tedious in their progress, and sometimes tax the constitutions of patients to the utmost limits of endurance.

The amount of substance which is often lost in these injuries, whether primarily removed by the projectile itself, or by gangrene as a result of the crushing to which the parts have been subjected, is seldom fully replaced under any conditions of treatment, so that a depression or gap, more or less deep according to the nature of the wound, generally remains after the healing process is concluded. The cicatrisation is also frequently accompanied with adhesions of superficial to deeper parts, and a certain amount of contraction of the surrounding tissues, involving greater or less interruption to the normal functions of the limb or part of the body injured. The amount of functional interference resulting from the manner in which cicatrisation takes place, may often be modified by judicious arrangements on the part of the surgeon according to the situation of the injury. Due consideration must be given to the adhesions which are likely to occur during the treatment—when placing an excavated superficial wound in a position of rest, when arranging a limb with a deeply tunnelled wound on its pillow, when applying supports and making

other such local arrangements. The surgeon should take care that the position and modes of support which he selects are such as will not only afford ease to the patient, but will conduce to repair being accomplished with least impairment of the functions of the organs with which the wounded parts are associated. When the healing process is completed, the thin and easily ulcerable cicatricial integument which has been formed will generally require to be protected for a time by some appropriate covering to shield it against accidental injury.

CHAPTER V

INSTRUMENTS FOR THE DETECTION AND EXTRACTION OF FOREIGN BODIES LODGED IN GUNSHOT WOUNDS

General remarks.—The general principles on which the exploration is conducted for the detection of foreign bodies lodged in wounds, as well as the ordinary means employed for the purpose, have been described in the chapter on the treatment of gunshot injuries after the arrival of patients at a field hospital. It was then mentioned that the use of special instruments is sometimes necessary to determine whether foreign substances are or are not lodging in wounds. This necessity is chiefly experienced in general hospitals where patients are admitted in the later stages of their wounds, but exceptionally is occasionally met with in the earlier periods of such injuries. The present chapter contains a description of the principal exploring instruments which have been employed in such cases.

The usual modes of extracting foreign bodies after their lodgment has been determined were also described in the chapter on local treatment of wounds. It was considered more convenient, however, to postpone the description of the instruments themselves to a later part of the work, and this will follow the remarks on exploring instruments.

The observations in the present chapter will thus embrace: (1) a description of the instruments employed in certain special cases for the detection of lodged foreign bodies; and (2) a description of some of the instruments employed for extracting them.

(1.) *Exploring Instruments.*

Exploring instruments for cases of suspected lodgment.—It has been already mentioned that in the majority of gunshot wounds when foreign bodies happen to be lodged in them, there is no difficulty in detecting them by the finger or long silver

probe, especially metallic substances as bullets and fragments of shell, when an early search has been made for them. The instruments now to be described are only intended for use when the exploration by the surgeon's finger is impracticable, and when the trial by the probe has been attended with doubtful results, so that no satisfactory conclusion as to the lodgment or absence of foreign bodies could be arrived at. Difficulties of this kind sometimes happen in situations where they might least be expected to be met with, but generally occur in wounds which have their terminations at or near some of the solid structures of the body. They may be encountered in recent wounds, especially deep and narrow wounds made by small fragments of shell or pistol shot; but they occur more often in older wounds in which the tracks of the missiles have become contracted to narrow sinuses, and in which the directions of these sinuses have become tortuous or otherwise intricate. The finger may not be able to penetrate the small and constricted passage; and the probe, even if it be enabled to traverse it and happen to reach a hard substance, may fail to give the desired information as to its nature—whether it be bone or a foreign body that is touched by it.

It may be readily ascertained by striking or rubbing a metal bullet out of the body with a silver probe, and comparing the sensation conveyed to the fingers with that which is experienced when a piece of bone is struck or rubbed, that the difference between them is so marked, scarcely any one could be deceived, even with the eyes shut, as to their respective qualities. But when the bullet or piece of bone is at the bottom of a wound, and the probe comes in contact with the side of the wound, especially if particles of bone are scattered about, or if any membranous tissues intervene between the end of the probe and the object impinged upon by it, it will be found the sensation conveyed to the fingers is so complex that a precise diagnosis is rendered exceedingly difficult.

No more remarkable illustration of the difficulty adverted to could be adduced, perhaps, than that which was afforded by the wound received at Mentana by General Garibaldi. In his case the entrance-opening presented to the surgeon consisted of a slit through the integument and a fissure across the base of the inner malleolus. The fissure in the bone was not wide enough to admit a finger; and an ordinary probe, when passed through the cleft, failed to give satisfactory evidence for deciding the important question whether the bullet was impacted in bone near the ankle-joint or not. Some of the ablest surgeons in Europe, after exploring, were led to declare that no foreign body had become lodged in the wound. And this occurred in a case where the track left by the projectile was not much more, if any more, than an inch in depth, in which the track was not tortuous, nor among intricate tissues.

Nélaton's probe.—Dr. Nélaton, after his visit to General Garibaldi, felt assured, from general circumstances, that the bullet had become lodged, and was led to think of various devices for obtaining demonstrative proof that his opinion was correct. His first idea was to obtain a steel probe cut like a file at one extremity. He presumed that by passing such an instrument down to the substance which he suspected might be the bullet, and by giving it a rotatory motion, sufficient would be brought away on the teeth of the file to determine its nature. While he was having this instrument made, he thought of chemical reagents, which had been tried before in similar cases of doubt, though without success.[20] Acting on this idea, M. Nélaton applied to M. E. Rousseau, an eminent chemist, to furnish him with means of determining the presence of lead in a wound by chemical analysis. M. Rousseau then suggested the introduction of a substance capable of bringing away a metallic impression should metal be present, such as rough porcelain, and so enabling the metal to be recognised not only by chemical reaction but by its ordinary physical signs. This suggestion led to the construction of the instrument which, since its successful application in Garibaldi's case by Professor Zannetti, to whom it was sent by Dr. Nélaton, has become known as Nélaton's probe.

Fig. 45.

Nélaton's Probe.

Nelaton's probe (fig. 45) consists of a slender rod of metal, 5 or 6 inches in length, terminated at one end by a small knob of white, unglazed, biscuit china. The other extremity of the probe is furnished with a small handle, grooved ridge-and-furrow fashion, in order that the finger and thumb may the more easily roll it between them, while the porcelain knob is being pressed at the bottom of the wound against the suspected foreign body. If it be a leaden bullet against which the porcelain is rubbed, a very distinct mark of lead is impressed on it. The bullet itself is thus caused to give ocular demonstration of its presence. If the foreign body be iron, having a rusty surface, a stain of rust will be found on the china.

The round ball of china which is fitted to the Nélaton test-probes frequently has a diameter of about a quarter of an inch. This is sometimes large enough to render its passage difficult through a fistulous track among fibrous tissues, such as is occasionally met with as a chronic result of a gunshot wound. A sinus of this kind, unless connected with necrosed bone, usually leads a military surgeon to suspect it is due to the lodgment of some foreign body which had passed along it at the time of the original wound. It is therefore just a case in which such a test-probe may afford

valuable diagnostic aid to the surgeon, but the size of the porcelain knob sometimes interferes with the attainment of this object. A probe tipped with a piece of the biscuit china of less diameter, more oval in form, with a flat extremity, may be obtained, and is more suitable for such a narrow fistulous track. In a recent wound the larger round ball is more convenient. It is not so readily impeded in its passage along the wound, and the impression made by the lead upon it is more obvious to observation.

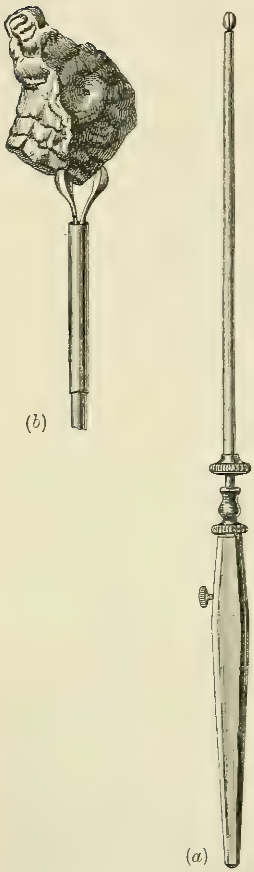
It is evident, from the nature of the test-probe just described, that direct and firm contact between the porcelain and the metal is essential in order to get the evidence which the surgeon requires. If there be merely a little blood, serum, or soft coagulum in front of the metal, pressure by Nélaton's probe will squeeze it away, and the mark can be obtained; but if any resisting medium, however thin—thin membrane, for example—happen to be placed between the surfaces of the metal and the china, no impression will be made on the latter. And there are various substances which are liable to be so interposed—such as muscular or cellular tissue pushed by the knob of porcelain itself before it; pieces of linen, cloth, paper, or other substances which have entered with the bullet; a piece or edge of bone projecting in front of it, and other such obstacles. The ill result of such an occurrence may not simply be that no impression is obtained; but a surgeon may be misled into an erroneous conclusion that no missile is lodged although there may be one, because the evidence of the lodgment is not seen. This may cause delay in the healing process, which might have been avoided had a correct diagnosis been established and the foreign body removed.

Lecomte's stylet-pince.—To obviate all such sources of fallacy, Dr. Lecomte of the French army invented an instrument to which he gave the name of 'probe-nippers' (*stylet-pince*). His design was not merely to indicate the presence of a foreign body by bringing away a mark of its presence, but by bringing away a small portion of the substance itself. The instrument could not only be used for bringing away a scale of lead, but also a minute portion of paper, cloth, wood, or any other foreign body capable of being cut in a similar manner. If the supposed foreign body were a fragment of bone, it would equally bring away a particle of it. The stylet-pince was provided with hard steel nippers, with a stem of sufficient length and fineness to be passed along a narrow sinus, while at the same time it was solid enough to bear a considerable strain in use.

The instrument consists of two portions: the first is a solid steel rod of small diameter, fixed in an ivory handle at one extremity, and cleft at the other into two small branches, each of which terminates in a little cup-like blade or curette; the second is a slender canula, which glides backward and forward,

but only within a limited distance, along this rod. The central rod is fixed in the handle by means of a side screw, which can be loosened at pleasure by the surgeon, so as to increase the length of the part of it which is exposed, or to enable it to be removed altogether to be cleaned. The two steel curettes have very fine and sharp edges. They separate from each other by the elasticity of the steel branches, of which they are the terminations; but they are easily brought together by the pressure of the canula when it is caused to glide along the central rod up to them. When thus brought together, the two curettes fit one to the other and form a smooth steel rounded extremity, about one-third of the usual size of the china knob of a Nélaton probe.

Fig. 46.



Lecomte's Stylet-Pince. (*a*) The curettes closed; (*b*) the curettes open, and grasping the edge of a deformed bullet.

It will be apparent, from the description, that the gliding of the canula determines the opening and closing of the curettes: when it is slipped back, the curettes open; when it is pushed forward, they are closed, and then constitute a little hollow globe. There is no difficulty in the manipulation of the instrument. It is inserted with the curettes closed, and is used just as any other probe would be. In order to determine the nature of the substance with which the probe is in contact, its canula is drawn towards the surgeon, at the same time that its extremity is kept pressing against the substance. This movement has opened the curettes. A similar pressure is maintained while the canula is pushed home, and this causes the curettes to be brought together again; their edges, as they close towards each other, nipping off a small particle of the substance over which they are moved. The instrument is then withdrawn, and supposing it to have been brought into contact with a leaden bullet, a small scale of lead will be brought away enclosed within the cavity formed by the two united curettes. The glistening surface of the freshly cut shaving of lead will sufficiently indicate its nature. If any difficulty should occur in distinguishing the nature of the particle which has

been enclosed, it can be removed from the curettes, and observation under a magnifying lens will show what the substance is. The stylet-pince is thus a most useful explorer for deciding doubtful cases of lodgment of all foreign bodies which can be cut by hardened steel; it responds with even more distinctness than the Nélaton probe in the cases in which that test would be of service, while it answers for a variety of other cases in which the Nélaton probe would give no indication at all. Lecomte's instrument will scratch, but will not clip off a particle of the cupro-nickel cover of the Lee-Metford rifle bullet, though it will a portion of the hard lead of its core, if it happen to be exposed. When it is important to solve a doubt respecting the presence of metal in a case where a foreign body has been found to be too hard to be cut by the curettes, the application of an electric indicator will probably be found to be the easiest mode of settling the question.

Electric indicators.—Electricity has been long suggested as a means of detecting metallic substances lodged in wounds; and very ingenious appliances have been lately contrived for the purpose. One of the first to try the use of an electric apparatus was M. Fontan, a French military surgeon, who derived the suggestion from Professor Favre of Marseilles.[21] Two insulated conducting-wires, ending in steel points, were connected with a small galvanic battery. One of the wires was in communication with a galvanometer. When the points were brought into contact with a piece of metal lodged in a wound, the circuit being completed, the needle of the galvanometer was deflected. An instrument of this kind was used in Garibaldi's case, but by some mishap the two points were not brought into contact with the lodged bullet, and no indication of its presence was obtained.[22]

The improvements which have taken place in the modern applications of electricity have led to more simple and yet more sensitive bullet explorers being devised. One of these, the invention of Mr. De Wilde, is on the principle of an electric bell. The action is excited in a suitable cell, and is increased in intensity by the intervention of a multiplying coil. A special exploring probe is connected by insulated wires with the apparatus, and the indication, when the circuit is completed by contact of the two points of the probe with a bullet or fragment of iron shell, is given by the striking of a hammer against an alarum-bell. The bell sounds at each renewal of contact of the points with the metal. The exploring probe consists of a long slender tube of smooth vulcanite, containing two insulated needles, the points of which can be withdrawn within the tube, or be made to protrude, at the pleasure of the operator. Altogether it is an effective appliance as an exploring instrument, owing to the strength of the electric current developed, and the marked manner in which the indications are given when a metallic substance is met with. There is also attached to the

instrument a bullet extractor, the two arms of which are insulated, and so arranged that when they are connected with the battery they indicate the grasping of the foreign body similarly by the sound of the bell. Unless the metal be firmly grasped by both blades, without any other substance intervening, the indication will not of course be given. M. Kovacs, a Hungarian physician at Pesth, and Professor Neudörfer, have designed instruments on a similar principle.

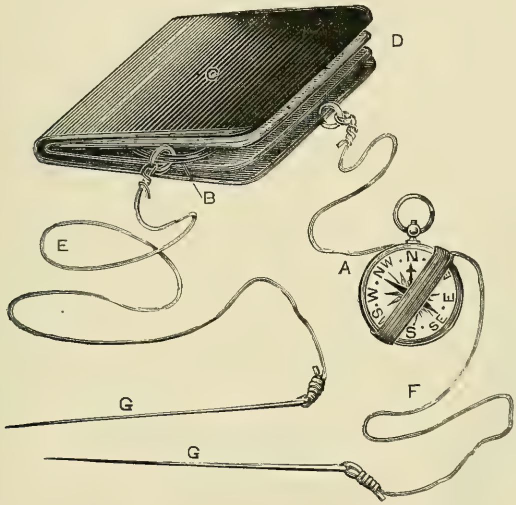
Another electric indicator has been made by Messrs. Krohne & Seseman of London, in which the proof of contact with a lodged metallic substance is afforded by the movements of a fine needle upon a small dial-plate, in the same manner as in the single-needle telegraph instruments. Attached to the instrument are not only an insulated bullet extractor and explorer, but also a pair of acupuncture needles adapted for use in cases where metallic bodies are supposed to be lodged in soft tissues after a wound is healed, or away from any means of approach by an open wound or sinus.

Both De Wilde's and Messrs. Krohne & Seseman's electric indicators have been frequently used with advantage among invalided soldiers at Netley. In one case a patient had been wounded in the outer part of the thigh by a missile two years before admission. The wound had healed in due course without the presence of a foreign body in it such as a bullet having been suspected. On his admission a small fixed tumour was felt in the upper part of the ham, deeply placed between the hamstrings. There was nothing to give assurance that it was the bullet, but on passing down the acupressure needles of Krohne & Seseman's electric apparatus the necessary proof of its being a metallic substance was at once obtained. The extraction was then proceeded with without any hesitation. A soldier who had been wounded in the Ashanti war just above the right ear and adjoining part of the head, suffered from frontal headache, especially on the right side. The wound was soundly healed. On the right temple, not far from the scar of the wound, there was a diffused hard swelling, which had been regarded as the result of periostitis. It was fixed, smooth on the surface, and without any defined edge. A suspicion arose that it might be lead spread out over the bone. Two needles were successively passed, as in the case before mentioned, and the electric indicator decided the question. An incision was made, and the lead, which was found to be flattened out and closely applied to the bone, was extracted. In another case, in which a man had been wounded in the thigh in the Ashanti war and the wound was healed, a hard nodule was felt near the seat of the injury. It was obviously a foreign body, but the electric needles gave no sign of metal in this case. It had been previously ascertained that the nodules of ironstone, which were sometimes used by the Ashantis as fire-arm projectiles, had

no power to deflect the electric indicator, and the substance was therefore suspected to be one of these missiles. On extraction it proved to be an ironstone slug as supposed.[23]

A rough but sufficiently effective electric instrument for determining the presence of metallic substances when they are suspected to be lodged in gunshot wounds can be improvised in the following way. The magnet of an ordinary pocket-compass, which has had some turns of wire covered with thread wound round it as an induction coil, is employed for the electric indicator; while a copper coin with a small plate of zinc, but separated from it by flannel padding saturated with diluted acid, forms the voltaic pile.

FIG. 47.



(*a*) Pocket-compass with several turns of covered wire wound round it; (*b*) copper coin; (*c*) folded plate of zinc; (*d*) flannel saturated with diluted acid; (*e f*) insulated wires; (*g g*) exploring needles.

The exploring instrument is formed by two insulated wires, bound together, but with the points left free, or by two acupressure needles attached to them. When these parts are connected, and the circuit is completed by contact with metal, the indication is given by movement of the magnet of the compass. Dr. Althaus refers to a very simple contrivance of a similar nature by Dr. Oscar Liebreich of Berlin.

Endoscopic exploration.—A form of endoscope has been suggested for use in exploring for foreign bodies in wounds. Dr. Fenger of Copenhagen has stated that he was enabled in several instances, on examining wounds inflicted during the late Franco-German war, to see their interiors distinctly by means of the

endoscope, without causing pain, hæmorrhage, or any subsequent irritation.[24] But it has never been turned to a practically useful account so far as I am aware; though in case of a projectile being suspected to be lodged in the bladder, and perhaps in some other instances, it might possibly be used with advantage.

(2.) *Instruments for the Extraction of Foreign Bodies from Gunshot Wounds.*

Three different classes of extracting instruments.—The instruments which have been devised for removing missiles and other substances which have become lodged in gunshot wounds are exceedingly numerous. The greater number of them, however, although differing in particular points of detail, may be classed under one or other of three mechanical contrivances, viz., (*a*) the Forceps, (*b*) the Scoop, and (*c*) the Screw. Some composite forms of extractors consist of a combination of two, while a few comprise all three of these appliances. It will be useful to give a brief account of a few instruments in each of the three classes, selecting those which possess special features or have been designed to meet special needs.[25]

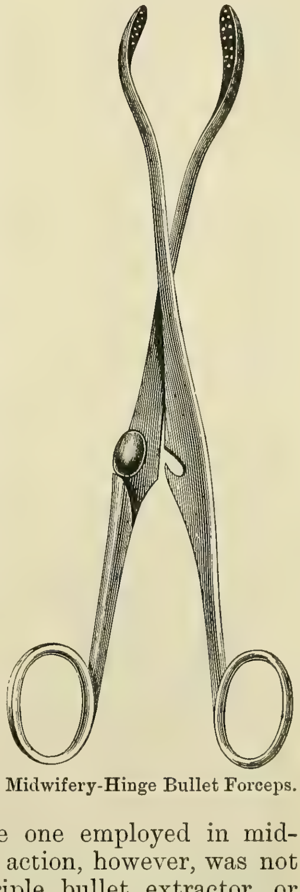
(*a.*) **Extractors of the forceps class.**—The varieties comprised in this class are very numerous. A multitude of examples, many of fanciful shapes, are figured in the works of ancient surgeons. Modern extracting forceps chiefly vary in the shapes of the blades, modes of grasping, the manner in which the grasp of the foreign body when caught between the blades is secured, the connections of the stems, the relative lengths of the stems above and below their point of juncture, and the extent of separation of the stems required for getting a foreign body between the blades. The following seem to be the requisite qualities of an extracting instrument. The shape of the combined blades should be such as to enable them readily to grasp bullets of the forms in ordinary use, and at the same time to seize and hold missiles of irregular shapes. The stems should be so connected, and of such length, as neither to stretch injuriously the contused tissues of the wound during their insertion, nor at the time of being opened for grasping the body which the operator is seeking to remove; and lastly, there should be means, when once a foreign body has been grasped, of holding it securely, so that it may not be liable to slip or be drawn away during the process of taking the instrument out of the wound.

The ordinary dressing forceps in a surgeon's pocket-case of instruments may be regarded as an extractor of this class; for it is very commonly employed for removing foreign substances which have lodged superficially, whether they are lying near the wound of entrance, or only seen after being exposed elsewhere by

incision. But it is only serviceable when a foreign body is very near the surface. Its blades are not fitted for holding securely bodies with smooth and convex surfaces; and the stems are usually so hinged together, that, if they are inserted deeply, they do harm from the width to which they have to be opened in order to grasp the foreign body, and consequently by distending and bruising the tissues along which they have been passed.

Old pattern regulation bullet forceps.—This instrument, which had nearly hemispherical blades, suitable for holding a spherical bullet, was defective in several respects. The stems were much bowed outwards, and were connected by an ordinary hinge, which was placed at a short distance, 2 inches, from the blades. The stems were thus divided into two very short arms between the hinge and the blades, and two long arms, each 5 inches in length, between the hinge and the handles. The ill effect of this arrangement was that to separate the blades sufficiently for seizing a lodged projectile, the long arms had to be widely separated, and the wound of entrance and track of the missile were subjected to distension of a very mischievous character. These inconveniences became aggravated in proportion to the time occupied and to the movements made in searching for the foreign body, and in the endeavours to grasp and remove it — operations which it is not possible to prevent from being protracted in occasional cases. The defective character of this instrument, especially as regards the position of the hinge, is found in not a few instruments of comparatively recent construction.

Fig. 48.



Midwifery-Hinge Bullet Forceps.

Midwifery-hinge bullet forceps.—The injurious distending effects, just described, of some extractors on the forceps principle, during efforts to grasp foreign bodies in wounds, caused an instrument on a different plan to be devised for use in the British army. Instead of the fixed hinge, a hinge similar to the one employed in midwifery forceps was adapted to it. The action, however, was not new. It existed in the celebrated triple bullet extractor, or tribulcon, invented by Baron Percy, and he himself referred the

idea to Maggius, a surgical author who wrote in the year 1548. By the division of the forceps into two parts, one stem could be first inserted, and, after insertion, could be used both as an explorer for finding the bullet, and as a director for the second blade to extract it after its site had been determined. As soon as the two stems came into proper juxtaposition, they became firmly connected with each other, both when separating the blades for grasping, and also when withdrawing the instrument, so long as the rings or handles by which the operator held the instrument were kept in proper relation to each other.

The hinge in this forceps, instead of being near the blades, is placed near to the handles. The long arms of the stems, 6 inches in length, are between the hinge and the blades; the short arms, 3½ inches in length, are between the hinge and the handles. The blades are curved, hollowed, and rasped on their inner surfaces. They were made oval in form to adapt them for receiving conoidal bullets within their grasp. At the same time, as they met at their extremities, they were well fitted for taking firm hold of bodies of irregular shapes, and of larger size than could readily be received within the cavities of the blades. This is still a very serviceable instrument for extracting fragments of stone, iron, and other such irregularly shaped missiles.

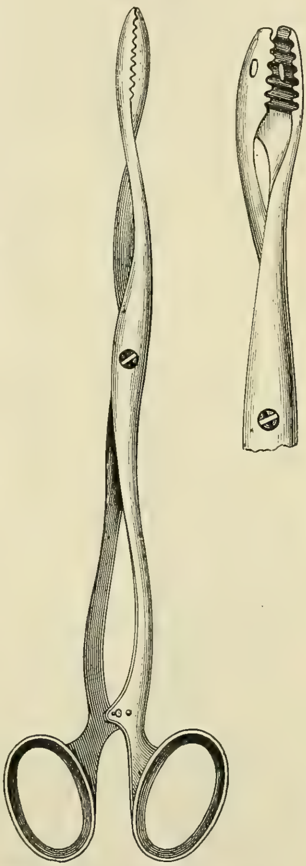
Weiss's ball-and-socket bullet forceps.—The same object that led to the construction of the midwifery-hinge forceps is aimed at in the mechanical arrangement of this forceps. One stem is made with a small spherical enlargement or ball, the other with a hollow socket in which the ball can revolve. The socket stem is deeply grooved from the socket to the blade. The ball stem is round, solid, and can be received into the groove of the socket stem, at the same time that the convex surface of its blade is received into the concavity of the opposite blade. The two stems can thus be combined, and act as a simple sound. If a foreign body be reached, the ball stem can be turned round and the concave aspects of the two blades be brought opposite to each other for grasping. It requires some practice to manipulate this instrument with adroitness, and the blades require to be adapted to the shapes of modern bullets.

Bullet forceps in use in the French army medical service.—This forceps consists of separate stems, so that one can be used as a sound. One stem cannot be used as a guide to the other, as may be done with the midwifery-hinged forceps; for, to lock them as shown in the sketch, they must be placed nearly at right angles to each other. Each stem is 5 inches in length from the handle to the joint, and 3 inches from the joint to the blade at its extremity. The blades are oval, and each has a small aperture in its centre. Their edges are deeply serrated. Each stem is slightly curved in opposite directions before and behind the hinge. The portions of

the stems to which the blades are attached work with a cross action, and thus distension of the bullet track is avoided as much as possible. After a foreign body is grasped the two stems of the instrument can be pinned together near the rings or handle by suitable movements of the operator's thumb and finger within the rings, and then the foreign body remains fixed in the grasp of the blades, independently of the operator's hand. This forceps is well designed, strong, and handy, for the extraction of missiles of moderate dimensions.

Tieman's mouse-toothed bullet forceps.—An extractor belonging to the class of forceps instruments, but different in design from the kinds previously described, was manufactured by Messrs. Tieman of New York, and was greatly praised during the war of the rebellion in the United States. It was similar to the sharp-pointed bullet forceps previously made by Luer of Paris; the only difference being that in Luer's instrument an additional provision was made for fixing the arms together after the teeth had been imbedded in the bullet. The arms of this forceps are straight, slender, and joined by an ordinary hinge; but instead of terminating in hollow blades, they are furnished with two pointed extremities, 'long and stout teeth,' which, when closed, overlie each other in such a way as to present a smooth and blunt surface to any object with which they may be brought into contact. When the curved points are separated, they are adapted for biting into any relatively soft substance, such as lead, which may be placed between them. They cannot fix their teeth in a fragment of iron shell, or into a steel-mantled bullet, but can penetrate the cupro-nickel cover of a Lee-Metford bullet sufficiently to get a firm hold of it. This compound metal, though not so soft as lead, is nevertheless softer than the steel points of the forceps. But from the slenderness of the arms of which the teeth are the terminal points, the arms are apt to twist and to loosen their hold, unless they are drawn carefully and in a straight direction

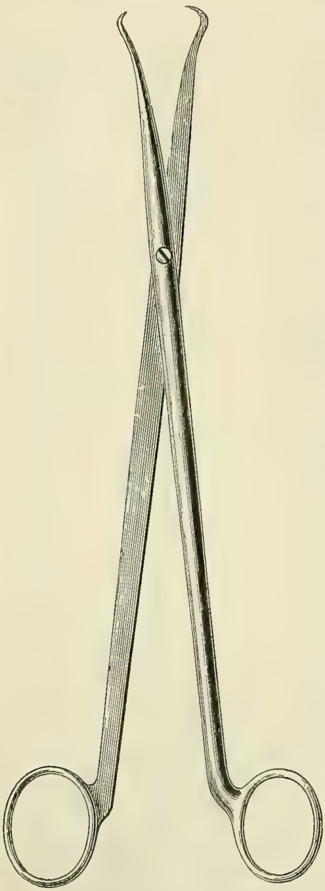
Fig. 49.



French Army Bullet Forceps.

from the place where the bullet has been grasped. This tendency to twist can be avoided by strengthening the arms, and causing them each to end in two points instead of a single one. Forceps have been made for extracting foreign bodies on this plan, so that they form a sort of vulsellum, and even more teeth have been added behind the front teeth. But the great objection to all such sharp-pointed forceps is that they are hardly safe instruments, particularly in the hands of novices, when foreign bodies are lodged among important bodily tissues.

Fig. 50.



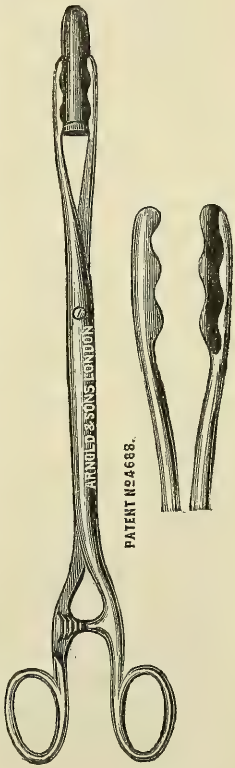
Tieman's Bullet Forceps.

Although when the forceps is inserted into a wound with its teeth closed it may push aside any blood-vessel or nerve which presents itself, and so may ensure these structures against injury from its points, this offers no security against their being pierced after the claws have been opened and the sharp points are brought towards each other again, or as the instrument is moved about, in the efforts to fix them into the supposed foreign body; nor even, when the points are imbedded in a bullet, against tissues being at the same time hooked inwards and held within the space included between the bullet and the short arms of the instrument. Repeated observations made with such instruments for practising the extraction of bullets from the dead body have shown that, on efforts being made to grasp bullets, the teeth of the instruments have bitten into tissues which have come in their way, and that, too, without conveying any perceptible sensation to the hands of the operators that they have done so. The penetration of the tissues is only made known, indeed, when traction is made upon them in the process of withdrawing the instrument from the wound or by subsequent inspection. Moreover, frequent mistakes were found to be made in the conclusions arrived at respecting a foreign body having been grasped between the teeth, especially when the position of the object sought for was one of much depth and out of sight.

The penetrating power and firm tenacity of grasp of such pointed instruments, when they are applied to substances capable of being penetrated by them, is undoubtedly very great. No forceps, however, depending upon sharp points for its grasp can be employed without causing unnecessary hazard to a wounded man whenever the foreign body to be removed is not in view, for injury can be so much more readily inflicted by a pointed instrument, and so much more unconsciously to the operator, than can happen with extracting instruments which terminate in blunt, smoothly rounded blades, when they are properly used.

Forceps for modern small-bore bullets.—The holding power of the varieties of bullet forceps hitherto described partly depends on their capacity for biting into a metal such as lead, a power which they no longer possess when the projectile is protected by a steel or other cover nearly as hard or harder than themselves. In order to get a secure hold of such an armoured projectile, supposing it to preserve its original form, the hollow parts of the two blades should correspond closely with its shape when it has been seized lengthwise, so that it may not slip away from the forceps in the efforts at extraction, or it must be held in suitable depressions when it is caught crosswise. By this latter contrivance it will be grasped securely until it can be adjusted into the position of its long diameter in the forceps by the aid of the surgeon's finger prior to extraction.

Fig. 51.



Forceps for Small-bore Bullets.

Messrs. Arnold of London, under direction of Professor Stevenson of Netley, have contrived a bullet extractor on the above-named principles. They have modified the dimensions of the ordinary bullet forceps, so as to adapt it for securely holding the armoured bullets of ·303-inch diameter used with the Lee-Metford rifle, as well as for other small-bore rifle bullets. The blades are scooped, and each scoop presents a concavity of about 1 inch in length, and $\frac{1}{4}$ inch in width. Two transverse grooves are added for securing the grasp of a narrow bullet if one should chance to be laid hold of athwart the blades. The scoops are not roughened on their inner surfaces as the hold is sufficiently firm without this addition, owing to the manner in which the edges of the scoops are made to overlap and enclose any narrow bullet which may be

caught and held between them. The hold of the bullet by the forceps is not so absolute as it would be if the forceps were pronged, and the prongs were hooked into its surface; but it is so securely held that none of the natural tissues through which the forceps would have to pass when being withdrawn from a wound could displace the projectile, while the objections to the addition of teeth which have already been mentioned are avoided. Externally the blades are smooth and polished, and sufficiently narrow when closed to pass without difficulty along any narrow bullet track which is not tortuous in direction. The whole instrument is 9½ inches long. The projections of the ridge-and-furrow contrivance near the handles by which the blades are locked when a bullet is held between them, are so inclined that a simple sliding pressure of the surgeon's thumb and finger readily serves to fix or unfix them, and the arms of the forceps do not require one of them to be tilted upwards, as is necessary in the French and some other instruments, for fixing the two arms together.

Delorme's bullet extractor.—A similar modification of the bullet forceps hitherto used in the French army, but differing in some of its details from the English extractor, has been designed by Professor Delorme of Paris, for withdrawing compound rifle bullets of 8 mm. diameter from wounds. A figure of this instrument, drawn by Professor Delorme, appears as one of the illustrations in the second volume, recently published, of his work on Military Surgery.[26] The excavations of the blades are cylindrical, and equal in length to that of the 8 mm. bullet, viz., 1·25 inch. Their extremities are rounded and smooth externally, and their lip-like terminations are fully open, so that one of the 8 mm. bullets when placed longitudinally can lie between them and the hollows of the blades, as in a bed fitted to receive it. The concave surfaces have a series of rather deep transverse grooves to assist in maintaining the grasp of a bullet when lying between the blades. The sides of the blades have an opening for receiving a bullet in case one should be laid hold of transversely.

Three-bladed forceps.—Grasping instruments have been constructed with three instead of two claws. Some of them are of ancient, some of modern invention. The 'Alphonsinum,' invented by Alphonse Ferrius early in the sixteenth century, was an instrument of this character; and several others with triple claws are figured in old works.

Ruspini's bullet extractor.—In 1813 Mr. Ruspini published an account of his three-bladed instrument for extracting balls from gunshot wounds.[27] It was estimated so highly at the time that a large sum of money was awarded by the Government to its designer for inventing it. The object of the instrument was stated to be in the first place to act as a probe, and secondly, to do away with the necessity of enlarging the openings of wounds either by incision

or dilatation. It consisted of a silver tube, to the extremity of which three claws, each 2 inches in length, were attached by hinges. The claws, when closed together, formed a smooth conical end to the instrument. The claws were capable of being separated from each other by three short springs, which were acted upon by a screw near the handle and a rod passing through the tube of the instrument. The same rod, on a foreign body being grasped by the claws, could cause them to close together upon it.

Ruspini's bullet extractor was issued in army supplies for many years, but has long been abandoned from practical experience of its inefficiency. The idea, however, has been frequently repeated by inventors. It was complicated in construction, liable to get out of order, and was not strong enough to withdraw a projectile, even though it had succeeded in grasping it, when much opposition was offered to its removal by the surrounding tissues. The levers by means of which the blades were opened were very short and weak, and no further power could be brought to act upon the blades than what these levers supplied.

Goodchild's bullet extractor.—This is a steel three-bladed forceps, invented by Dr. Goodchild when surgeon of the 1st Warwick Militia Regiment. It resembles Ruspini's forceps in several respects, but differs in the mechanism by which the blades are opened and closed. The opening of the blades is produced by the action of a central rod and screw, together with the elasticity of the blades themselves ; while their closure is effected by the action of the screw in the opposite direction. The blades or claws are 2 inches in length when fully expanded, and can be drawn 1 inch into a canula by the screw action. The *grasping* power of Goodchild's instrument is much superior to Ruspini's, and the construction being simpler, it is less likely to get out of order.

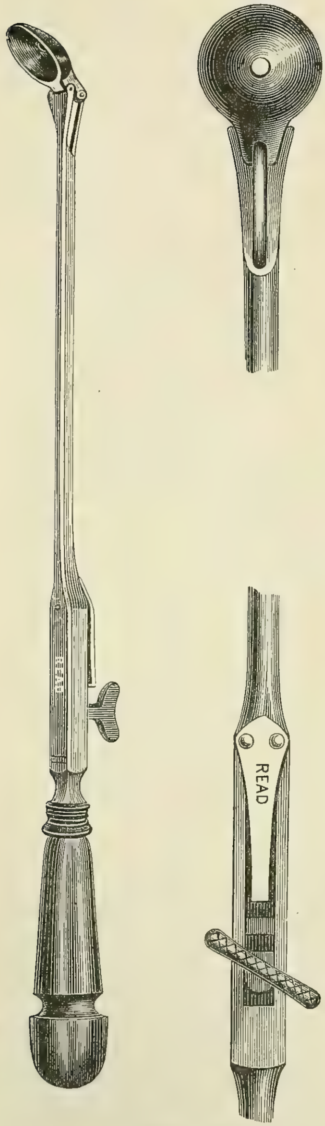
(*b.*) **Bullet extractors of the scoop class.**—Scoops are employed with a view to remove bullets by lifting them out from their place of lodgment, and then exerting traction. The position of the bullet having been ascertained, the scoop is passed behind it, and on the instrument being carefully withdrawn from the wound, the bullet is brought away in front of the scoop. Some surgeons consider the scoop a safer appliance than instruments which act by grasping; and also that, when once in front of a scoop, a bullet is less liable to slip away during the extraction than if it were held by pressure between the blades of a forceps.

Ingenious mechanical contrivances have been applied to bullet scoops with a view to facilitate the passage of the instrument along a wound by keeping the scoop, or spoon part of the instrument, in line with the handle until the bullet is reached, and then arranging for the scoop to turn behind it. Weiss's and Tufnell's bullet scoops are examples of different contrivances for this purpose.

Simple scoops.—Ordinary bullet scoops consist of slender

steel rods flattened in the centre, and terminating at each extremity in a spoon-like scoop, the concavity of which is rasped to ensure a better hold. They are made of different lengths, from 6 to 9 inches long, and the scoops vary in size, shape, curvature, and depth.

Fig. 52.



Tufnell's Bullet Scoop.

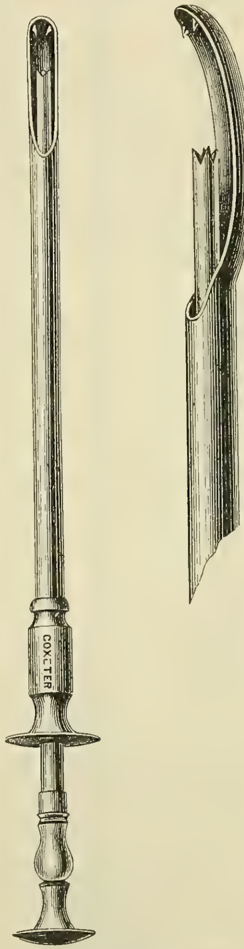
Weiss's bullet scoop.—In this extractor the scoop is fixed, and forms the termination of the main stem of the instrument. Its special feature is the contrivance for deepening the scoop at pleasure by means of a supplementary spring. At the back of the scoop is a steel slide, worked by a thumb-piece at the handle. On pressing the thumb-piece, the end of the steel slide is caused to partially curl round the scoop, and thus proportionably to increase its concavity.

It does not often happen in practice that scoops can be passed behind projectiles in the manner contemplated. Difficulties are constantly experienced in disentangling missiles from the tissues among which they are imbedded, especially when they have rough and irregular surfaces. The additional assistance of a finger in the wound then becomes necessary. One of the arms of the midwifery-hinge forceps can be used as a scoop, and may occasionally be so employed with success when the wound admits the surgeon's finger in addition. The projectile can then be loosened from the tissues among which it is held, and being pressed by the end of the finger against the blade, can be securely retained while being drawn away from the wound.

Tufnell's bullet scoop.—In this instance the scoop, which was circular in form, was hinged to a slender steel rod which passed through the hollow stem of the instrument, and was connected with a small spring thumb-piece and sliding bar near the handle. When the

sliding bar was drawn backwards, the scoop was maintained in the same line as the stem of the instrument; when the bar was pushed fully forwards, the connected rod caused the scoop to be placed at right angles with the stem. The difficulty in the use of the instrument was the liability of the scoop to drag forward some of the tissues which might accidentally be brought in front of it at the time it was made to turn on the stem, or subsequently. Some of these scoops were issued to surgeons for use during the Crimean war, but they were not favourably regarded.

Fig. 53.



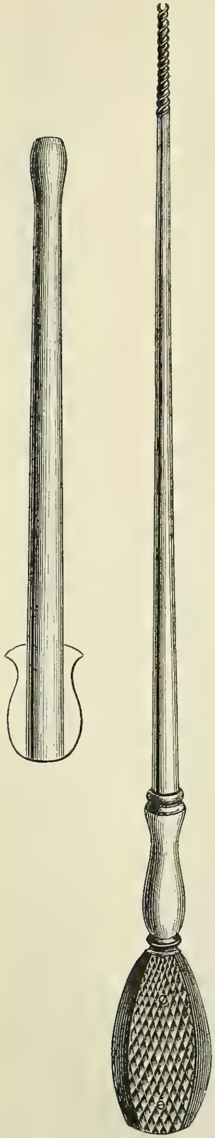
Coxeter's Bullet Extractor.

Coxeter's bullet extractor.—The want felt of some means of fixing a projectile in position after it had been got in front of a scoop led to the invention of this instrument. Until a few years ago it was included in the surgeon's 'capital case of instruments.' It consists of a canula between 6 and 7 inches long, terminating in a slightly curved scoop, the concavity of which near its edge is fitted with two small and sharp spikes. Through the canula a steel rod passes freely. It can be drawn into the canula or pushed downwards toward the scoop by means of a suitable handle. The end of the rod terminates in four points. If a leaden bullet or small fragment of shell be caught within the scoop, the central rod or pin can be pressed down upon it so as to maintain it in its position. No distension of the track through which a projectile has passed is caused while it is in use either as an exploring sound or as an extractor. It would hardly, however, be of service with the small-bore bullets of the present time, though useful for the extraction of other projectiles. It was much used during the Crimean war.

(*c.*) **Extractors of the screw class.**—These instruments appear to have been more frequently employed by Continental than by British surgeons. One of them has long been authorised for use in the French service, under the name of the 'Tire-fond' and Baudens' bullet extractor. The patterns in the collection of the Army Medical School are of different lengths, from 12 to 7 inches

long. Each consists of a steel rod, having a convenient handle for grasping at one end, and at the other a screw composed of a double thread. The screw is long and slender, the base being continuous and corresponding in size with the shaft of the instrument, and from thence gradually tapering towards its point. By means of the double thread, the distance between the threads of the screw is diminished; and thus, assisted by the length of the lever or handle, the mechanical power of penetration of the instrument is greatly increased. The instrument is provided with a canula, shorter by an inch or so than its own length. Its purpose is to act as a sheath, to protect the sides of the wound from injury by the points and spirals of the screw, while the instrument is being inserted. When the rounded end of the canula has reached the foreign body, the canula is drawn upwards toward the handle, and thus leaves the screw exposed and ready to bore its way into the body opposed to it.

Fig. 54.



Tire-fond Bullet Extractor.

It is obvious that such an instrument can only be usefully employed when the foreign body is soft enough to admit of being penetrated by the screw, and when the parts behind it offer sufficient resistance to the pressure exerted upon them for it to remain stable during the manipulation for effecting its penetration. Among soft tissues, or in the spongy tissue of the end of a bone, its pressure would simply have the effect of forcing the lodged substance before it into a deeper position. Extractors of the screw kind can therefore hardly be useful in any cases excepting those in which leaden bullets are lodged, are firmly impacted in the shafts of bones, and can be exposed to view. If a bullet be lodged in the spongy tissue of a bone, other means must be adopted to effect its removal.

(*d.*) **Bullet extractors of the composite class.**—Instruments have been devised with the object of supporting the foreign body to be extracted, and thus protecting the surrounding tissues from undue pressure while the screw is employed to penetrate its substance; in other words, for adapting screw extractors to remove leaden

bullets lodged among the soft tissues of the body. The following is one of these instruments.

Tuson's bullet extractor.—This extractor, the invention of Dr. Tuson of H.M.'s Indian army, resembles Ruspini's and Goodchild's extractors in being a tripartite expanding screw forceps, but differs from them in the purpose to which the central steel rod is applied. The rod is armed with a two-threaded screw at its extremity. It is capable of being moved backwards and forwards, and is designed for fixing the bullet more securely when caught within the three blades of the forceps. This three-bladed forceps does not appear, however, to have the same grasping and holding power as a simpler two-bladed forceps. The three blades, when expanded to their ordinary limits, present a circumference of 3 inches, and can be expanded to give a circumference of nearly 5 inches. Such an amount of distension might be injurious in the hands of an unskilled operator.

Percy's tribulcon.—A compound instrument, which for many years had a great reputation, was contrived by Baron Percy, who gave to it the name of the triple tire-balle or tribulcon.[28] A forceps, a curette or scoop, and a tire-fond screw are combined in it. In using this instrument as a forceps, the construction enabled each branch to be inserted separately. The scoop was made of the same shape as the scoop which was then generally used in lithotomy. The tire-fond was without a canula, but Percy maintained that a canula was of no value in the use of this part of the instrument.

Dr. Mouij's tire-balle.—This is an ingenious but complex instrument, designed for being turned to various purposes in the exploration of wounds and the extraction of foreign bodies. The inventor has had in view an instrument suitable in size for being carried in a surgeon's pocket-case, and has therefore made it as light in weight and portable as practicable. It comprises a forceps, a screw or tire-fond, and a Nélaton probe. These appliances are intended to be used either for direct or tortuous wounds; for the latter a flexible portion is supplied. The inventor claims for it the following advantages: (1) the blades of the forceps are so constructed and toothed as to be able to grasp a missile at any part of its outline, so that it matters not what its shape or position may be; (2) it is not necessary that the blades should grasp the whole of the projectile; (3) a sufficient portion of the substance can be detached, if desired, to recognise the presence of metal without a magnifying-glass; and (4) with the extractor arranged for tortuous tubes, foreign bodies can be taken out of a natural passage such as the œsophagus with facility.[29]

Barclay's case of bullet-extracting instruments.—The difficulty of extraction is sometimes greatly increased when a missile has been lodged long enough to have become encysted. The cyst

wall or bands of fibrous tissue will sometimes be so strongly fastened to an irregularly distorted bullet that a separation can only be effected by forcibly tearing or cutting them asunder. The difficulty which results from this intimate connection is one which surgeons must be prepared to meet when operating for the extraction of any missile after a prolonged period of lodgment. The late Surgeon-General Dr. Barclay, owing to repeated experience of this particular complication, caused to be made for him a pocket-case of extracting instruments, including one specially suited for dividing the fibro-cellular entanglements of lodged projectiles, so as to facilitate their subsequent removal by the instruments designed for extraction. Dr. Barclay presented a case of these instruments to the Museum of Military Surgery at Netley.

The case contains: 1st. Three pairs of spring forceps. Each forceps is armed at its grasping ends with a set of teeth, which lock into each other when the ends are in contact. The ends differ in width, and the teeth vary in number and direction in each forceps. All these have been devised for *biting into* a projectile so as to prevent it slipping away from the hold of the instrument. 2nd. A duplex scoop 6 inches long. The two scooped extremities vary in width. This instrument is intended for withdrawing foreign bodies with the aid of a finger. 3rd. A bistoury with the blade much curved. It has a sharp edge on the convex side, and is devised for dividing either cellular envelopes, as previously mentioned, or bands of adhesion, when they impede the extraction. The instruments in this case, like some of the others described, have lost much of their value since the introduction of armoured rifle bullets. But from the special circumstances of the occasions on which English military surgeons often have to perform their duties, and the various kinds of fire-arms, often very old kinds, which are employed by half-civilised peoples against British troops, some of the instruments which would be only exceptionally serviceable in European warfare are still required for use in English hospitals. Some of the bullet forceps hitherto in general use, such as Coxeter's bullet forceps for extracting bullets lodged in narrow tracks, and the midwifery-hinge forceps for removing large irregular missiles, would be far more useful in practice among men who had been wounded in the frontier wars of India or in Burmah than the best designed instruments for the extraction of the European small-bore bullets with hardened envelopes would be. It is well, therefore, that they should be retained among the instruments placed at the disposal of British army surgeons for general use in warfare.

CHAPTER VI

CONSTITUTIONAL TREATMENT OF WOUNDED SOLDIERS IN TIME OF WAR

Exhaustion among men wounded in the field. — Having considered the local treatment in the field and field hospitals of patients suffering from gunshot wounds, it is necessary to glance at the general or constitutional treatment which should accompany it. It is hardly too much to say that next to arresting conditions which threaten the immediate extinction of life, such as loss of blood from wounded vessels and extreme shock, there is nothing more important for the welfare, and sometimes for the safety of men who are badly wounded than the early administration, occasionally of a moderate stimulant, and always of proper nutrient support. This support is as necessary, in the early condition in which wounded men are usually found, as a preventive against mischief, as its subsequent administration is for maintaining a healthy process of repair in their wounds. It is true that remarkable instances of recovery occasionally occur under circumstances of extreme neglect, of exposure, and enforced abstinence, extending over several days and nights. It may be admitted that rather than crowd wounded men in confined rooms, it is better to subject them to all sorts of inclemency of weather in the open air; but it is certain that a considerable number of wounded men will sink under such circumstances, unable to resist the prostration due to the want of means of counteracting the depressed state of system, physical and moral, into which they are thrown by their injuries and the exposure combined. In many, no rallying, or only very partial reaction from the condition of collapse, takes place; the heart's action flags more and more, and eventually stops altogether. It is notorious that soldiers, although appearing to present a high standard of physical strength in campaigning, are often only stimulated to this appearance by the excitement of the circumstances in which they are placed. As soon as this excitement ceases, and the condition of tension is succeeded by one of enervation, as usually happens when a soldier is placed *hors de combat;* when the man is suddenly removed from a condition of extreme bodily activity in the discharge of his duties, and of mental diversion owing to the constantly recurring changes of scene which accompany them, and, instead, is reduced by injury to a state of enforced quietude in an ambulance, and is probably oppressed by pain and anxiety; then the previous fatigue, the broken rest, irregularity of meals, and the disturbance of his ordinary habits of life, which he has

been undergoing during the campaign, soon manifest their effects by a state of constitutional exhaustion in the patient.

This exhaustion happens even under favourable hygienic circumstances in campaigning. Even among the troops of the Federal armies during the war of the rebellion in the United States, notwithstanding all the liberal supplies and scientific skill devoted to the preservation of their health, the fatigues and circumstances of the prolonged war induced a prevailing condition of exhaustion, which in many instances influenced unfavourably the results of treatment both of sickness and injury. It is, of course, much more marked when the circumstances in which the soldier has been placed have been unfavourable to bodily vigour and health. When a campaign has been carried on in a marshy or otherwise unhealthy country; when troops have been camped in tents, overcrowded or too closely pitched together; when they have been exposed to any deleterious epidemic influence, or subjected to wet and much vicissitude of weather; if they have been shut up in a besieged town or fortress; and especially if they have been badly nourished—a deteriorated state of body approaching to a scorbutic taint is engendered before the ordinary signs of this disorder are manifested, and the depression that follows disablement from injury becomes proportionably all the more profound.

In all campaigns in which the rations have been coarse and deficient in nutritious qualities, without sufficient variation and ill-cooked, a weak and impoverished condition of constitution, closely allied to that of scurvy, and frequently scurvy itself, have been from this cause alone gradually engendered among the troops. Hence, when wounds have occurred, many of them, which might have taken on a healthy action under other circumstances, have only progressed from bad to worse, until in a large proportion of instances a fatal termination has closed the scene. Gangrene, pyæmia, bowel diseases, fevers, and other grave complications find a ready soil and ready means of development among wounded men when a scorbutic condition of constitution has been induced by the long-continued use of food inadequate in nutritive value to meet the physical wear and tear to which the troops have been subjected during a campaign, especially when this defective nutrition has been joined with some of the other unhygienic conditions which have been previously mentioned. The influence of the unwholesome diet, combined with the unsanitary conditions to which the British troops were subjected in Bulgaria,[30] contributed in a great measure to the untoward results that attended many of the wounds received in the first great battle—that on the Alma—after the landing in the Crimea; while it favoured the scorbutic taint, which gradually became fully developed under the privations of the first winter in the Crimea itself, and was the chief source of the unhealthy action taken by the wounds (fortunately com-

paratively few in number) received during that period of the war. In all prolonged sieges, down to the siege of Paris in 1870, especially at the later periods of them, the difficulty of treating wounds with success among the besieged has been greatly enhanced by the deteriorating effects of the scarcity, privations, and unhygienic conditions to which the patients have been previously subjected. Depression of bodily energy, from whatever cause it may arise, unless it can be removed by judicious care and treatment, must always form a grave feature in the condition of a wounded man. Of course, if his depressed state should have been complicated with any considerable loss of blood at the time of the injury; or if excessive cold and damp are present to assist in enfeebling the general circulation, as was the case during the winter of 1854–55 in the Crimea, the hazardous character of this exhaustion becomes aggravated in a greatly increased degree.

Necessity for early nutrient support.—From all that has been previously said, it follows that in all severe gunshot wounds inflicted during a campaign, but especially whenever there has been previous constitutional deterioration, the administration, as early as practicable, of warm nourishment in a suitable form is a point of much importance. The first object is to prevent the wounded man sinking so low as to make it a matter of uncertainty whether he will be able to mount from his state of exhaustion again; the second is to increase the vigour of his constitution, and prepare it for future trials. The restorative powers must be rallied, and also maintained, that they may have a fair chance of being able to resist the depressing influences of hospital confinement, and at the same time have the requisite energy for repairing the injury which has been inflicted. To accomplish the first purpose, it is often better to postpone the primary examination and dressings at the ambulance or hospital until some suitable refreshment has been taken, than to postpone the nourishment till the dressing has been done. This will especially be the case if much time has elapsed between the receipt of the wound and the removal into hospital; if the patient is cold from having been lying a long time on the ground where he has fallen, from exposure at night, or if there be so many wounded that a good deal of delay must occur before all can be surgically attended to. The free use of good nourishment before and after their injuries was one of the advantages which the British wounded enjoyed in the Crimea after the first winter had passed, and was probably one important source of the different results of the treatment in the English and French hospitals during the latter period of the campaign; and almost all the surgeons who were engaged in practice during the great civil war in the United States refer to the liberal and varied dietary given to the wounded in the field and general hospitals as having been one

of the chief causes of the general success which attended their treatment.

Constitutional conditions of wounded patients.—Many gunshot wounds, owing to improved methods of treatment, become healed without any constitutional disturbance or interruption. Others, from various causes, do not progress so favourably, but pass through periods of suppuration, or sloughing, and granulation, as of old, before they become cicatrised. In such cases successive changes in constitutional condition may usually be noticed. The first is generally a condition of depression more or less prolonged, according to the specific nature of the wound, its concomitant circumstances, and the patient's degree of strength; the second, one of simple reaction of varying amount; the third, a condition of constitutional irritability, more or less marked, which continues during the suppurative and reparative stages of the injury.

Constitutional treatment during the first stage.—The necessity for restoratives in the shape of moderate doses of stimulants, warm refreshing beverages, and proper nutriments in the first condition has been sufficiently remarked upon. All that can usually be done to meet this need on the field of battle itself, even though the ground may be clear of the enemy, is to give a little spirit and water to an exhausted patient. This will enable him to bear the transportation to the first dressing-station better. On arrival at it, some of the medical comforts provided in the bearer-company's waggons or field panniers ought to be administered as speedily as circumstances allow. These consist of such articles as cocoa-milk, tea, arrowroot, and the concentrated extract of meat for forming beef-tea. It is advised that finely broken-up biscuit or some farinaceous article should be added to the beef-tea to increase its nutritive quality. If the field hospitals be established in houses or other buildings where the opportunity is afforded for making such arrangements, or if the patients can be carried at once from the field into hospitals of a more permanent character, as may happen in besieged places, then, whenever necessary, in addition to warm stimulants or warm broth, warmth and reaction should be encouraged by getting the patients speedily into bed, applying heat to the extremities, and adopting any other means available for accomplishing the purpose.

An excess of alcoholic stimulation must be particularly guarded against in the first stage of depression, as indeed it should be throughout the whole course of treatment. The exhibition of an undue quantity of alcoholic beverage ceases to be a simple restorative; it creates an over-excitement which must lead to a proportionate depression of energy afterwards. The amount of stimulus that is confined to simply restoring the disturbed balance of power for the time will be serviceable; all stimulus beyond what will

contribute to this result will be hurtful. There is little probability of nutrient restoratives being given in excess at the first period of treatment; if they are exhibited beyond the powers of the patient to assimilate them, either he will refuse them when offered, or, if he swallow them, the stomach will reject them. With alcoholic drinks the case is different; the habits of many soldiers, and the nature of such stimulants, cause an excessive quantity to be very readily taken. There is an unfortunate custom in some armies of issuing a spirit ration to the men shortly before going into action. It is a most pernicious practice under the usual circumstances of warfare; for although it may stimulate soldiers during a limited time, if the engagement be prolonged, it will not fail in the end to make them more exhausted than they would have been if they had not taken it. To soldiers who fall badly wounded it is especially hurtful: it intensifies thirst, leads to increased depression, and often prepares the way for serious complications when their wounds are of a grave character. The treatment of men who have been drinking a considerable quantity of spirituous liquor immediately before the receipt of their wounds requires great caution, and is always a matter of special difficulty.

Constitutional treatment during the second stage.—During the stage of reaction the power of assimilating food, as well as the desire for it, will in a great measure be wanting; so that still only nutrients in a very diluted and easily assimilable form are admissible. Two things usually attract attention in this stage—the local reaction at the seat of injury, and the systemic reaction. These are in part independent of each other, in part dependent on each other. If the wound be one not involving organs of first importance, and the patient be in a sound condition, the reaction, both local and general, under favourable hospital circumstances, will be so moderate as to cause no anxiety to a surgeon. If a similar wound occur in a patient debilitated by long-continued fatigue or exposure to unhygienic conditions, the reaction may be very different in degree and in its nature. Other causes—the extent of the injury, its nature and complications, a plethoric condition of the patient, previous panic and nervous excitement—may induce excessive reaction, and the question of the proper treatment to be pursued becomes one requiring careful consideration. In former days bleeding was freely resorted to under such circumstances. Venesection was supposed to be absolutely necessary to restrain the vascular excitement within moderate limits. Depletion in various other forms was also resorted to. Nauseants, purgatives, restriction in diet and drinks, were called into requisition to aid the antiphlogistic treatment. Few modern surgeons believe that such a drain on the circulation, or such depressing medicines and regimen, are beneficial, much less

necessary. The prevailing conviction now is, that although under their influence excess of inflammatory action may be reduced, the vital power of the patient is reduced beyond proportion, so that he is often left without the means necessary for a favourable reparation of the structures which have been mutilated by the shot, or for the healing process in case amputation has to be resorted to. He is also rendered less able to resist the deteriorating effects of confinement and loss of exercise, as well as the influence of the morbific agents to which he must be more or less subjected during a prolonged period of hospital treatment. At the best, after such depletory treatment, the rate of the patient's convalescence is slow. It is on this reasoning that modern surgeons avoid abstraction of blood in all but exceptional cases, and employ only the mildest forms of remedial agents in their attempts to keep the vascular excitement during the condition of reaction within due limits. Rest, as complete as possible, by the aid, if necessary, of chloral or morphine, the simpler kinds of diaphoretics and diuretics, acidulated drinks, are joined with the usual applications at the seat of injury, in order to calm the inflammatory excitement, local and general, which is occasionally met with at this stage.

If there be much pain about the wound, opium in some of its forms may be freely given with advantage. The value of this remedy consists not merely in the reduction of the local pain and in soothing spasm, but also in lessening the irritation which results from them. It procures that ease and repose which are essential for the restoration of the balance between the variously disturbed functions of the patient's frame. During the last few years the hypodermic administration of morphine has come into general use; and when due precautions are taken as to the quantity employed, as to the state of the patient, that he is free from severe shock or collapse, there can be no doubt that it possesses many advantages over all other modes of administering opium in gunshot wounds accompanied with pain, and that, under the conditions named, it may be used from the first with much advantage. Relief from pain is afforded by it with much greater certainty and with much more speed than when any form of the drug is given by the mouth. The stomach and digestive organs in patients suffering from the irritation of painful gunshot wounds are often in such a condition that considerable quantities of an opiate may be swallowed without much apparent effect; it remains inert, or nearly so, for the time, while a very minute quantity injected under the skin suffices in a few minutes to induce the desired result. The means of administering hypodermic injections of morphia are now contained in the Field Hospital Equipment of all European armies.

Chloral was extensively used as a calmative remedy in gunshot wounds during the Franco-German war of 1870–71. Baron

Langenbeck praised its employment highly, especially for allaying spasm after amputations necessitated by gunshot wounds. He considered it superior to opium for this purpose. The combination of the bimeconate of morphia with the chloral has been stated to give increased efficiency to the drug. Fifteen grains of the hydrate of chloral with a third of a grain of the bimeconate have been recommended for forming a soothing draught to allay local traumatic irritation and to induce sleep in all painful gunshot injuries.

The mention of sedatives leads me to refer to the use of tobacco. Although smoking is only permitted under certain restrictions, and in exceptional cases, in the wards of English permanent military hospitals, it is rarely objected to in field hospitals. The only sound objection to the consumption of tobacco is the danger of setting light to the bedding or tents, for there are few non-smokers among soldiers to whom the smell of tobacco is disagreeable, while to the majority it is not simply a luxury, but, from long habit, a daily necessary. Cleanliness, notwithstanding its use, can easily be provided for. It is questionable whether there is not more danger from fire when tobacco-smoking is not allowed, than when it is; for under the former arrangement the men, on the approach of an officer, frequently conceal their lighted pipes under the clothing, or they smoke at hours when they are not likely to be visited, and as this will be chiefly at night, it will be at a time when they are not unlikely to fall asleep and drop their lighted pipes unconsciously on the bedding. It is not, however, because smoking is a habit with soldiers the loss of which becomes a source of discomfort when it cannot be gratified, that the use of tobacco in field hospitals is to be recommended, but on account of its sedative qualities. No one can doubt that it has a soothing effect on men suffering from the pain of wounds, and produces a state of calm which is very beneficial under the circumstances. The contentment it affords to the patient helps the surgeon in his work, and enables a man to submit cheerfully to many unavoidable deprivations which, without it, would fret and worry him. Perhaps none of the presents from Aid Societies in time of war have been so much appreciated in hospitals as the presents of tobacco in various forms; for they have usually arrived at times when it has been difficult for patients to obtain supplies from other sources. It is not among the hospital supplies, though, considering its utility, it is doubtful whether it might not be made one with advantage for issue on special occasions.

Constitutional treatment during the third stage.—When the stage of reaction has subsided, when the tumefaction and inflammation about the seat of injury are declining, sloughs in progress of separation, suppuration fully established, and when the desire for food is improving, it is essential that no judicious means of com-

plying with this appetite, and so supporting the strength of the patient, should be neglected. No medicines are necessary, unless required for assisting the excretory organs, which are liable to become inactive from cessation of the movements to which the body has been accustomed when in a state of health. What the patient chiefly requires under such circumstances is food of a sufficiently varied character, as pure an atmosphere and as full a supply of it as can be obtained, and such cheerful diversion of his thoughts as the position in which he is placed will allow. Should hygienic rules have been enforced during the campaign, and the soldier have been in a good state of general health at the time he was wounded,[31] if the treatment named can be provided for him while he remains under hospital care, the wound will progress towards recovery with regularity, and the constitution of the patient will not be impaired in any material respect. When special states of constitution are met with, they must of course be specially dealt with; but the general principles of treatment ought always to remain the same as they have been described. It is during the stage of suppuration, which is liable to be protracted in some cases of gunshot injury, that the advantages of having fortified the wounded man by a supporting diet and regimen will be particularly made manifest. When the vitality of a patient, already in all probability lowered by previously exhausting agencies, has been further reduced by want of an adequately supporting treatment, he is unable to resist a tendency to morbid degenerating processes when he is placed in conditions which favour their development; he becomes unduly sensitive and irritable, and readily falls a victim to suppurative fever or to pyæmia, or becomes the subject of visceral disease, which ultimately leads to a fatal issue. There can be no doubt also that many of the cases of secondary hæmorrhage which occur in field hospitals among the wounded are attributable quite as much to lowered systemic vitality and septic influences as to the local injury.

At the same time that the necessity for well-cooked, attractive, and easily assimilated food is dwelt upon in the treatment of patients with gunshot wounds of a severe character, it is equally necessary for a surgeon to put the attendants on their guard against allowing an excess in quantity to be given to them. Cramming a patient who is unable to take exercise will in many instances not simply be of no use, but will be a positive source of detriment. Excess of food will disturb the digestive functions, irritate the constitution, increase the amount of suppuration, and impede the progress of cure. The food, while nutritious in character, should be limited to the amount that can be properly assimilated. It is the digestible quality of the articles, and not their largeness of quantity, that is of importance. The diet, so far as concerns the amount which is suitable, must be adapted to

the circumstances of each particular case. In addition to the ordinary articles of diet, fresh or dried fruits, if they are procurable, should be freely given; in their absence, vegetable-acid beverages—lemonade, tamarind, or lime-juice drink, rendered palatable—or other articles of a similar nature,[32] should be substituted for them. It is not to be expected that such things will be found among the regular supplies of field hospitals; but occasions will not unfrequently occur when they can be procured in general hospitals to which wounded men are removed from the field hospitals for further treatment, and these occasions should never be neglected. The necessity for the strictest cleanliness of hospital tents and wards with their precincts, of bedding and articles of apparel, of the clothing and persons of attendants, and the importance of regular and speedy removal of all soiled dressings and excreta, and of the constant purity of utensils and all hospital equipment, in order to maintain the atmosphere immediately about the wounds themselves in as pure a state as practicable, have been already adverted to when describing their local treatment. Purity of atmosphere is, however, of even greater importance as regards the constitutional health of the patients. A vitiated atmosphere, crowded with pathogenic micro-organisms, acts deleteriously enough on wounds locally if they are not sufficiently protected; but far more does it seem to act on them indirectly by its toxic effects on the general constitutional state of patients. In proportion as constitutional health becomes impaired, the healing process becomes less vigorous, takes place more slowly, and in deep gunshot wounds the tendency to diffusion of purulent secretions followed by unhealthy sinuous tracks and openings, as well as to accidents of a still graver nature, becomes more and more marked. Unfortunately, although all the necessary manipulative details to ensure cleanliness and to carry out antiseptic treatment may be duly attended to, there are often great difficulties in maintaining a sufficiently pure atmosphere in field hospitals. The accumulation of large numbers of wounded, which is usually unavoidable for some days after a great battle; the employment of buildings for intermediate hospitals which are of unsuitable construction, or objectionable from the condition of their environs; the want which frequently exists of means for separating the wounded from patients struck down by fevers and dysentery; these and other such circumstances entail special difficulties in the way of securing that purity of atmosphere which is essential for the favourable progress of patients labouring under sloughing and suppurating wounds. Special attention has been paid during recent years to the subject of distributing the sick and wounded of armies, as they accumulate, as widely as possible in tents or comparatively small hospitals, instead of aggregating them in a few large hospitals; and the importance of this dissemination,

and the steps necessary for effecting it, are better understood now than they were formerly.

When the plan of dispersing the wounded in small and widely separate hospitals cannot be carried into effect, and when, therefore, many wounded men have to be treated under the same roof, it must be borne in mind that the amount of fresh air to be supplied to the apartments in which they are placed ought always to be greater than need be given to patients affected with ordinary diseases. Perfect ventilation of the wards should be ensured whenever practicable; so that not only the air which is deteriorated by the ordinary causes of respiration and transpiration, but also the emanations from wounds, may be carried off as fast as any arise. To obtain this result there should be such arrangements with regard to inlet and outlet openings as will admit of about 3000 cubic feet of air traversing the ward hourly for each patient contained in it. We know how constantly this very essential part of the treatment of wounded men is neglected in the temporary hospitals employed in time of war, or is rendered impracticable from the nature of the buildings converted to hospital purposes; and this fact alone explains the often-repeated remark, that there would probably be a lower rate of mortality among the wounded if they were treated in the open air, notwithstanding exposure to rain and cold, than is usual among them when treated in buildings which appear to be all that is desirable from the protection and comfort they afford to the inmates.

The means of affording mental diversion to wounded soldiers in military hospitals in time of war have been greatly extended of late years. This improvement has been one of the results of the advance of civilisation. It has become understood that the exercise of the intellectual faculties, by means and within limits suited to the condition and circumstances of patients, is one ingredient in helping them towards recovery. The increased facilities of communication, locomotion, and transport have assisted in bringing these means within their reach in sufficient variety. The spread of sympathy in regard to the concerns and necessities of those who most directly suffer from the effects of war has also effected much in this direction. But it is questionable whether, with all the improvements that have been made in this respect, there is any form of diversion which satisfies for long together the mental wants of badly wounded men—who must often remain for considerable periods of time in a disabled condition—excepting complete removal to their own homes from the theatre of warfare when it is far away from their native country. To return to their own country and relatives is usually the one longing wish of wounded men, as soon as they have recovered so far as to feel themselves able to undertake the fatigue of the transport.

It is evident from the general tenor of the preceding remarks, that the most important part of the general or constitutional treatment of wounded men consists in maintaining them under favourable hygienic conditions. Implicit obedience to hygienic rules is essential, not merely for warding off fresh evils, but for keeping the constitutions of patients in such a state as will admit of their wounds pursuing a healthy course of action. If a certain number of wounds from their own nature may be expected, even under favourable hygienic circumstances—with a pure atmosphere, pure water, appropriate diet, and due attention to personal and surrounding cleanliness—to be attended with a given amount of disablement and mortality, that amount will be vastly increased from constitutional deterioration under unhygienic conditions, whatever may be the degree of surgical skill and nursing bestowed on the patients. The enforcement of hygienic requisites ought, it may therefore be said, to be the first and last subjects of consideration on the part of presiding surgeons, so far as the constitutional treatment of wounded patients is concerned.

CHAPTER VII

TREATMENT OF SECONDARY COMPLICATIONS OF GUNSHOT INJURIES

General remarks.—The treatment of gunshot injuries which has been described in the foregoing pages may be regarded as the preventive treatment of most of the secondary complications to which gunshot injuries are liable. If the local and general treatment which have been laid down be carried out, and the patients be placed under suitable hygienic surroundings, no secondary complications will arise in the majority of cases. They will occur on exceptional occasions where all the requisite steps have been taken to prevent their occurrence; but under such circumstances they will very rarely present a severe type, or spread so as to assume an epidemic character. On the other hand, they will very generally arise in some form or other where circumstances have occurred to prevent proper hygienic and surgical treatment of the patients being systematically practised, and under such circumstances may readily extend themselves and become generally prevalent.

It becomes necessary, therefore, to take into consideration the special treatment to be adopted when either one or other of the complications, elsewhere described, takes place. The treatment will be noticed in the order in which the complications themselves were described.

Treatment of inordinate inflammation in gunshot injuries.—It is a matter of first importance, when preparing to subdue excessive inflammatory action after gunshot injuries, to form a right opinion respecting the cause of the undue excitement, and to consider well the state of constitution of the patient in whom it occurs. The treatment which might judiciously be adopted for controlling inordinate inflammation of a sthenic character, would manifestly be calculated to do harm if it were of an opposite type. The depletory measures which might be advantageous in excessive inflammation attending a gunshot wound inflicted on a man of vigorous frame, could not be borne with impunity by another with reduced constitutional power; but would probably serve to give the inflammatory excitement further extension, and to make it more difficult of restraint. Fortunately among British soldiers wounded in the field, cases in which undue inflammation, when it occurs, is of a very low type, are seldom met with, and consequently the remedies which have to be resorted to among such patients in civil practice are rarely required in military hospitals at or near the front of the army. They are more liable to be met with in some of the hospitals to which the men are subsequently sent as invalids.

If the excess of inflammation can be traced to mechanical causes, such as violence to the wounded parts from bad or prolonged transport, rest and antiphlogistic remedies are plainly indicated as a first measure to be practised. Under all circumstances, so long as the inflammatory excitement lasts, rest is a most essential part of the treatment. This includes general rest of the limb or part of the body in which the injury is situated, and rest of the particular anatomical structures involved in it. The first or general rest will be best ensured by a judicious and easy position, aided by suitable support, so that all muscular strain is avoided. In using supports, undue pressure must be guarded against, so that neither the vascular nor the nervous circulation may in any degree be impeded. A judicious selection of supports as to their kind, and a judicious arrangement of them, become important matters to be considered according to the nature and site of each particular injury. Rest of the particular anatomical structures involved in the wound can be best ensured by interfering with them as little as possible after the general repose of the part of the body in which the wound is situated has been secured. Although there may be reason for suspecting that lodged foreign bodies have acted as a cause of the excess of inflammation, no search for them should be made, nor any efforts exerted to extract them while the action is high, unless they are clearly within easy reach. Such operative interference will probably add fuel to the fire, and, in occasional instances, may provoke serious aggravation of the complication present. Irrespective of the pain which such

proceedings cause in inflamed parts, nervous irritation will sometimes be set up which may easily pass beyond the limits of control. The exploration of gunshot wounds to search for foreign bodies in them when the parts concerned are in a high state of inflammation, is a most injudicious undertaking, and deserves strong disapprobation. Efforts should be made to soothe the inflamed parts as much as possible, and to reduce the inflammatory excitement within simple limits, and then, after the accomplishment of these objects, the exploration may be proceeded with, and foreign bodies, if detected, be removed. To reduce the inflammation, evaporating applications may be resorted to, at the same time that internal remedies calculated to reduce the force of the heart's action are administered. As a general rule, it is not desirable to apply too low a degree of cold to wounds in which inflammation has arisen in an inordinate degree. If moistened lint be applied, three or four layers of the material, placed one above the other, form a safer dressing than a single layer, by which a greater degree of cold is attained through more rapid evaporation. It is rarely advisable to abstract blood, even locally, from the patient; his strength rather requires to be economised for resisting the subsequent ordeal of depression which he will have to pass through when the stage of inflammatory excitement has subsided. But in cases in which considerable swelling around the wound and local congestion have taken place, in which the inflammation is accompanied with much pain and tension, and is causing constitutional disturbance, the employment of a few incisions to relieve the tension, and, aided by subsequent fomentation, to cause a moderate flow of blood, or the application of a few leeches if they are available, may cause relief and be productive of benefit. But all such proceedings should be carried out with proper antiseptic precautions. Subsequently, enveloping the parts in sublimate or other antiseptic wool forms a most appropriate and generally a most comfortable dressing, by its specific influence, by maintaining an even temperature, and by affording general support when covered with a light bandage. Some surgeons still advocate the application of large linseed-meal poultices, so as to enclose the wound and the whole of the inflamed parts adjoining it; but owing to their weight, soddening action, and other objectionable qualities, elsewhere alluded to, they tend to suppuration, and cannot be recommended for the purpose any more than they can be as applications to gunshot wounds in their early stages. The medicines employed should be calculated to excite moderate diaphoresis, to maintain regularity of the excretions, but should neither derange the stomach nor tend to debilitate the patient. Saline medicines, the mineral acids, and the milder diaphoretics, attention being given at the same time to the diet and drinks, so that these may be appropriate in kind and amount to the degree of pyrexial disturb-

ance present, are generally all that is required as regards constitutional remedies; while they will far less tend to interfere with a healthy process of repair in the wounded structures than remedies of a more severe and depressing nature.

The local application of ice, when it can be obtained, is advocated by some surgeons for the reduction of excessive inflammation accompanying gunshot wounds. In certain wounds, such as penetrating wounds of articulations, the use of ice for this purpose is often advantageous; but in most gunshot wounds of a severe character, especially in shell wounds, the vitality of the damaged tissues has been reduced to such an extent by the injury to which they have been subjected that the reduction of temperature and vascular action by ice becomes a hazardous proceeding. It increases the risk of rendering the inflammatory action destructive and of its leading to sloughing. It is all the more dangerous when the patients from any cause are reduced in constitutional strength. It is only in exceptional circumstances, as when the wounded are treated in towns or cities, that ice can be obtained for such purposes; and, even when available, it can for the most part be more beneficially employed in cooling the water or other beverages given to the patients, than as a local application.

The excess of inflammatory action under the treatment mentioned may subside, and the parts involved in it resume a healthy condition, or it may terminate in suppuration, the matter being discharged freely from the wound, or diffused among the tissues which had been subjected to the inflammatory excitement, or it may accumulate in isolated purulent collections. The treatment to be followed then becomes that of abscess, and is described elsewhere.

Treatment of gangrene in gunshot injuries.—The treatment of gangrene may most conveniently be noticed under the two forms which were mentioned in the remarks on this affection, viz., Local and Distant Gangrene.

Local gangrene.—The treatment of local gangrene, when it is limited to the parts which have been deprived of vitality by the direct crushing action of a projectile, is of a very simple character. Little more than protective measures are necessary while nature is engaged in the removal of the gangrenous tissues preliminary to repair. Rest, equable temperature, antiseptic dressings carefully applied, will usually suffice to ensure a steadily eliminative and healing progress in the wounded part.

If, however, the gangrene shows a disposition to spread, and the tissues surrounding the wound have been much bruised and infiltrated, there may be inflammation accompanied with tension and pain, or, without these active symptoms, the gangrene may be accompanied with constitutional depression, and then more special treatment becomes necessary. Strict antiseptic treatment should

be employed from the beginning; but constitutional remedies will often seem to have more influence in arresting the extension of this form of gangrene than local applications, whatever kind may be employed. The principle on which the general treatment should be conducted must be that of increasing the bodily strength of the patient. Stimulants in moderate quantities are often of essential benefit in counteracting the exhausting effects of the diseased condition, and in raising the flagging powers of the patient, so as to enable him to digest the food he is able to take. Nutriment should be given in concentrated, but at the same time easily assimilable forms. Small quantities frequently repeated are better for the purpose than larger amounts at longer intervals. The important point is to keep up the strength of the patient; for, in doing so, the textures adjoining the gangrenous parts will be better able to resist invasion, and the nervous irritability of the patient will be lessened. It may be taken as a rule that the more the gangrenous action shows a disposition to spread, the stronger is the evidence of some septic influence which is lowering the constitutional vigour of the patient, and consequently of the need of a supporting and strengthening line of treatment on the part of the surgeon.

If the gangrene be accompanied with much pain and disturbance of sleep, opium in some of its forms will usually be very beneficial. It may not only be administered as a medicine internally or subcutaneously, but may be applied locally, either by being dusted in the form of powder about the wound, or by being employed as a lotion. Quinine and the mineral acids, iron and other tonics are often beneficial. Such sources of irritation as intestinal accumulation must be carefully guarded against.

The fœtor is usually corrected by the antiseptic dressings. The carbolic acid, corrosive sublimate, iodoform, terebene, chlorinated lotions, and other applications of the kind are employed for the purpose.

Distant gangrene.—When gangrene threatens to commence at the termination of an extremity in consequence of a wound at its upper part having been attended with some lesion of the main vessels, so that the circulation through the limb has become more or less impeded, treatment should be adopted early with a view to prevent the threatened mischief. Efforts should be made to ensure the maintenance of a normal and equable temperature by enveloping the limb in cotton-wool, and by the application of artificial warmth, at the same time that the posture and kind of support most suitable for rendering the circulation easy through it are properly attended to.

When, however, gangrene declares itself decidedly, notwithstanding the preventive measures which have been adopted, and advances steadily up the limb, serious questions arise respecting

the proper treatment to be adopted: whether amputation must be resorted to at once; what should be its site if it be determined upon; or whether the operation may be delayed until the advance ceases, and a line of demarcation between the living and dead tissues is established. Some part of the decision on these points must always depend on the state of a patient's constitution. In a man with a strong and healthy frame, without much general excitement, the operation may be delayed, in the expectation that a line of demarcation will be naturally established; in one with a weakly frame, and with indications of commencing septic infection, amputation at the lower third of the thigh without delay will probably be the right course to pursue. If a limiting line be formed, the amputation may be usually performed with advantage in the healthy structures adjoining it. But the subject is one which always demands serious consideration. Connected with it are many special questions of practical importance which can only be thoroughly discussed in a systematic treatise on injuries of blood-vessels or on the subject of amputation.

Treatment of secondary hæmorrhage after gunshot injuries.—The many different circumstances which have been elsewhere enumerated as the occasional causes of this complication, sufficiently point to the different principles on which its treatment must be based in different cases.

The treatment of hæmorrhage occurring during an early period after a wound, and attributable either to local disturbance or fresh injury of a wounded vessel, or to increased arterial excitement, differs in no respect from the treatment of primary hæmorrhage. A knowledge of the sources of local injury sufficiently indicates what would have acted as means of prevention; but when a recurrence of bleeding has been thus accidentally set up, it must be controlled and arrested in the same way as if it were a first occurrence. Hæmorrhage produced by the effects of reaction on the circulation, or by cardiac excitement, must also be treated on the same principles as the arrest of primary bleeding, according to the nature, size, and situation of the vessels involved. This treatment has already been considered when describing that of primary hæmorrhage.

Secondary hæmorrhage, the result of a morbid process leading to ulceration or sloughing of the vascular coats, necessitates considerations over and above those which have to be given to hæmorrhage occurring at earlier periods. The state of the vessel itself, as well as of the surrounding structures, has become changed. Still the general rule is the same as in primary bleeding—viz., to place a ligature or ligatures at the part of the vessel from which the bleeding is taking place, instead of tying the vessel elsewhere at a distance from the wound. The same reasons hold good for this proceeding in secondary as in primary bleeding—viz., the

greater assurance given to the surgeon that the right vessel is ligatured, and the security afforded against a return of the bleeding, especially from the distal opening, through the influx from collateral branches. The operation is rendered more difficult on account of the generally infiltrated condition and altered aspect of the structures involved in the wound. Especial care has also to be taken not to ligature the bleeding vessel roughly, on account of its diminished elasticity and power of resistance. The unhealthy and more yielding condition of its outer tunic—the result of the morbid action to which the vessel has been subjected, and probably in part also to the effect of septic suppuration in the tissues surrounding it—has to be particularly taken into account in applying a ligature to it. The ligatures will have to be applied at a little distance from the bleeding aperture, in order to secure sufficiently sound and reliable parts of the vessel for their application. Some surgeons have objected to ligatures being placed near the bleeding part of the vessel in such cases, from a conviction that they will inevitably fail to accomplish their intended purpose in the altered condition of the vessels; but experience has proved that antiseptic ligatures, carefully applied, will sometimes retain their hold, both on vessels in suppurating wounds, and even in sloughing wounds; and, moreover, when the constitutional state and other circumstances are favourable, will lead to the obliteration of the tied vessel, as in other cases, and to permanent arrest of the bleeding. An attempt, therefore, should always be made, at any rate in the first instance, to secure the bleeding vessel in the wound itself, and to apply ligatures both above and below the opening whence the escape of blood is taking place, before resorting to other measures.

It can only be in rare and exceptional instances that the employment of styptics can be of permanent avail in such cases of secondary hæmorrhage; and, therefore, in all cases where the character of the hæmorrhage points to a vessel of considerable size as being the source of the flow, their employment had better be avoided. Their action on the tissues tends to lessen their vitality, and thus to place the parts in a condition favourable for the extension of the morbid action which has originated the existing mischief. The application of continued pressure by a tourniquet is also objectionable in cases of secondary hæmorrhage of ulcerative or sloughing origin. Pressure will generally have to be applied in the first instance when the bleeding occurs, but its prolongation should be avoided as far as practicable. Digital pressure, applied to the main trunk until more efficient surgical steps can be taken, is the least hurtful; but the sooner the bleeding vessel is fully exposed to view, and the orifices, if possible, secured by ligature, the better. When once secondary hæmorrhage has occurred to any considerable extent, and the evidence

sufficiently points to the bleeding having come from a vessel of important size—even though the flow may have spontaneously ceased or have been stopped by remedies of a temporary kind in the absence of the surgeon—the wound should be opened up as soon as practicable, and the bleeding vessel secured. The hæmorrhage may otherwise recur in the night, or at some other time when surgical help is not at hand, and a fatal result speedily ensue. If there is sufficient evidence to show that the bleeding has not proceeded from a large vessel, and if it have stopped by the time of the arrival of the surgeon, delay is allowable, for the arrest in such a case may prove to be permanent under proper care and treatment; but under opposite conditions delay is not justifiable.

Secondary hæmorrhage, the result of constitutional causes, such as scorbutic deterioration, peculiar states of the blood, in which its red particles are deficient, and its power of coagulation and plasticity lessened, is the most difficult of all kinds of bleeding to control. If the original wound be deep and of a severe character, secondary hæmorrhage occurring from large vessels can rarely under such circumstances be treated with permanent success by ordinary expedients. The artery itself is probably in an unsound condition, its coats softened or abnormally thin, and even though a ligature may stop the bleeding for a time, it soon makes its way through the vessel and becomes detached. The debilitated state of the patient's constitution having prevented the healthy protective action which might have taken place under other circumstances, the bleeding then recurs, and the patient's life is in greater hazard than ever. Under such circumstances it becomes an anxious question for a surgeon to decide whether the safety of the patient will not be best ensured by immediate amputation of the injured extremity. The extent and gravity of the wound, the state of the limb, the degree to which the constitutional powers of the patient are reduced, and the opportunities of watching the patient and of giving him due care and attention—hygienic and dietetic conditions being included in this last point—must all be considered in each particular instance before a decision can be come to on the proper treatment to be pursued. Similar difficulties occur when considering the most judicious treatment for secondary hæmorrhage proceeding from wounds in limbs, the large veins of which have become obstructed by thrombosis; as well as for that occurring in stumps after amputation. As a general rule the hæmorrhage is more under control in the stumps, because the whole face of the wound can be thoroughly exposed to view; but even in these cases, when the circulation of the limb is obstructed above, or when, from the unhealthy state of the patient, the stump shows a disposition to slough, or the arteries become opened by extension of ulcerative action to them, the attempts made to arrest the hæmorrhage will sometimes prove fruitless. The ques-

tion of re-amputation then arises, or of ligature of the principal artery of the limb with a view to giving time for the patient's health to improve and the stump to get into a more healthy state. Mr. Guthrie has advised that in such a case the shortest distance from the stump at which compression of the artery commands the bleeding should be carefully noted, and that at this spot a ligature should be applied, provided it be not within the sphere of the morbid process in the stump. If this plan prove unsuccessful, then recourse must be had to re-amputation.[33]

Treatment of hospital gangrene in gunshot wounds.—The treatment of hospital gangrene as practised by different military surgeons has varied very much according as they have considered the disease to be chiefly local or constitutional in its origin. Some have accordingly placed their chief reliance on topical, others on internal remedies. The most judicious treatment seems to have been when the two were combined. It is undoubtedly a form of disease in which local applications for the purpose of destroying the morbid action in the wound appear to be urgently indicated. It is usually so intense in character, and so rapidly destructive, that there is not time for arresting it by constitutional treatment only.

The first step to be taken by the surgeon must be to remove the infected patients from the sphere of those influences by which the occurrence of the disease has been favoured, if it have not been communicated by them. This must be done no less in the interest of the patients themselves, than to prevent the extension of the disease to other wounded men under treatment. As soon as a wound presents the appearances characteristic of hospital gangrene, the patient should be removed to another building and isolated. The isolation should be as complete as possible. Not only should the infected patients be segregated, but the surgeon in immediate charge and attendants should be debarred from attendance on other wounded patients. After dressing a patient suffering from hospital gangrene, the hands should be carefully disinfected. None of the utensils used by men suffering from the disease should be employed for other patients. In short, isolation should be not merely applied to the infected patients, but it should be extended, within the utmost limits practicable, to all persons in direct communication with them, and to all articles used by them.

At the same time, if possible, it will be better for the wounded men under treatment to have the advantage of a change of atmosphere. With this view they should be removed from any ward in which the hospital gangrene has appeared, and either be placed in tents or huts, or taken to a fresh building in which free ventilation can be secured. This is especially necessary if the walls and floors of the hospital in which the gangrene has appeared are of an absorbent nature. If this change cannot be made, the

unaffected patients who must remain in the wards where the disease has shown itself should be separated as widely as possible from each other, so as to give them the most copious aëration, and to prevent concentration of wound effluvia to the utmost available extent.

The most rigid attention to cleanliness; to the prevention of transmission of infectious particles from patient to patient by the hands of surgeons or dressers, or by means of articles employed in cleaning wounds, such as tow, water, &c. (the use of sponges should never be permitted); to freedom of ventilation; to the immediate destruction by fire of all foul dressings; to the removal of rubbish, stagnant water, and all objectionable matters in the precincts of the hospital building, should be insisted upon. The efficiency of the drainage, and all other hygienic matters, should be strictly attended to.

All dressings employed should be strictly antiseptic; the perchloride of mercury, carbolic acid, and iodoform being probably the most reliable bases of them. If, however, these applications do not appear to arrest the progress of the morbid action, other means must be resorted to.

A very large variety of substances, escharotic, stimulant, and sedative, have been employed as local remedies in hospital gangrene after ordinary applications have failed. Among British surgeons the undiluted mineral acids, especially the nitric acid and the liquor arsenicalis, have been the two remedies most employed. When one of the strong mineral acids is used, an anæsthetic should be administered, the parts surrounding the gangrenous tissues protected by a thick layer of ointment, the sore freed from sloughs and moisture as much as possible by means of pads of tow, and the acid applied steadily to the surface until it presents the appearance of a tough fibrinous mass; until, in short, the qualities of its substance are completely destroyed. Lint wetted with perchloride of mercury or carbolic acid lotion should then be laid over the sore. The acid may be applied by means of a piece of lint rolled round the end of a glass rod. Another plan of using the nitric acid has been to cause it to destroy a circle of skin and subcutaneous areolar tissue around the diseased part, so as to isolate it from the sound structures. When the yellow coriaceous slough becomes detached, it will probably carry with it the gangrenous surface of the sore, and the wound may then granulate healthily. This does not appear to be so reliable a mode as the former one. The pain resulting from the application of the acid does not usually last long.

It is equally necessary to give attention to cleansing the surface of the gangrenous parts before applying the liquor arsenicalis to them. When they are cleansed, lint soaked in the arsenical solution, diluted with an equal part of water, is applied, and is to be renewed at intervals of half-an-hour. Mr. Blackadder, who

first employed this remedy, and has written with much emphasis on its efficacy, has stated that the best plan is to continue applying it until an insensible, dark-coloured, dry slough is formed upon the whole surface of the sore, and the patient becomes relieved of pain.

Various other substances have been occasionally employed. Bromine, in its pure liquid form as well as in combination with bromide of potassium, was largely employed during the United States war, and is described as having proved beneficial in arresting the disease. Dr. Goldsmith, U. S. Vols., to whom its introduction as an agent for the control of this disease is stated to have been chiefly due,[34] directs that the parts are first to be dried by the application of charpie; then the sloughs, if thick, should be trimmed out with forceps and scissors as much as possible, for the thinner the slough the more effectual is the remedy. The parts having again been dried, the solution is applied by means of a mop, or a pointed stick of wood, in quantities sufficient to saturate the sloughs. If the sloughs undermine the skin, or dip down into intermuscular spaces, the solution must be made to follow, with the pointed stick, or by means of a glass syringe. The remedy should be reapplied every second hour as long as any odour of putrefaction is present, or as long as the sloughs appear to be diffluent.

The actual cautery was largely employed during the late Franco-German war by German surgeons. The reports regarding its use tended to show that hospital gangrene might be arrested by this form of remedy with more certainty than by any other. The irons were applied at a red or even white heat. In using the cautery, as with all other caustics, it must be remembered that the object is to penetrate completely the gangrenous parts, and to destroy a layer of the sound tissues beneath. If any poisoned portion be allowed to remain untouched, the disease will probably spread from that point. The surgeon must have a full conviction of the necessity for a complete destruction of the diseased structures to enable him resolutely to burn them to the requisite depth. As the iron, though red-hot when applied, soon becomes cooled by acting on the moist pulpy substance, which is more resisting to the burning action of the cautery than might at first be supposed, it is necessary to have several cauterising irons ready for use in each case. They should be applied while the patient is narcotised by chloroform or ether. In cases where a large surface has to be cauterised, it is convenient to remove as much as possible of the pulpy gangrenous tissues previously, and then to dry the surface as far as practicable with some carbolised tow. Portions of the edges, if much undermined, may also be cut away with advantage before the cauterising irons are applied.

It is only right to state, on the other hand, that, according to reports by Dr. Reeb respecting the treatment of hospital gangrene in the French Military Hospital at Strasburg, and by Dr. Bongard respecting its treatment in Belgium during the war of 1870–71, quoted by Dr. Chenu,[35] the actual cautery did not in their hands arrest its progress. Both of these surgeons have reported that they had better success with simple lemon-juice applied by pads of charpie two or three times a day. The use of the actual cautery is also stated to have been attended with but little success at Paris, where hospital gangrene extensively prevailed during the siege.

Whatever caustic applications may be used, when the charred tissues and sloughs are detached, and a granulating surface obtained, the wound may then be treated with any of the usual antiseptic dressings; its previous condition of disease appears to exercise no influence upon its future progress when once the morbid action has been fully checked.

The constitutional treatment must vary with the varying states of patients. Some surgeons have strongly advocated the administration of an emetic on the first signs of an attack of hospital gangrene being observed.[36] The necessity for giving an active purgative in the outset has also been generally noticed. The careless habits of soldiers frequently render a thorough evacuation of the bowels necessary before resorting to other remedies. The excretions, as well as secretions, are particularly liable to be very irregular in this disease, and their regulation becomes a necessary part of the treatment. The administration of iron, quinine, or one of the mineral acids, is generally serviceable. Pain must be alleviated, excitement allayed, and sleep procured by opium in some of its forms, or by other remedies having a sedative tendency.

Venesection combined with antiphlogistic remedies was formerly stated to be very beneficial. The removal of a moderate amount of blood may be occasionally useful when men with slight wounds happen to be attacked by the gangrene, and when the disease manifests itself in an active form, with accompanying high fever; but other means, as antimonial preparations, and medicines of a like character, are generally preferred by modern surgeons for lessening the constitutional and local excitement. Certainly no one would now practise venesection as it was recommended by Staff-Surgeon Dr. Boggie,[37] whose advice and example seem to have led to bleeding being a favourite treatment among many surgeons of the Peninsular period.[38] Hennen has recorded that the practice of venesection, introduced by Dr. Boggie at one period, became general in the treatment of the Bilbao hospital gangrene, and that it was regarded both by surgeons and patients as very advantageous. To modern surgeons it seems only reason-

able to conclude that the greatly lessened ratio of mortality in hospital gangrene of late years, compared with what the records show it to have been during the Peninsular war, may be greatly due to the abandonment of the practice of bleeding for its relief.

The records of the disease and its treatment handed down to us from the time of the Peninsular war seem to warrant the inference that hospital gangrene was of a much more inflammatory and sthenic type then than it has been during later wars. It was remarked in Germany that most of the severely wounded Germans, and still more the wounded French prisoners, especially if they had been long in the field before receiving their wounds, reached the country in a condition of great general debility. The fatigues of the campaign, the effects of their wounds, the hospital confinement, the insufficient attention after battles which left overwhelming numbers of wounded in the hands of the surgeons, reduced the physical powers of the men so rapidly and seriously that they generally arrived in a very sickly and depressed state. Suitable nutrient support, with a moderate amount of stimulants, cautious nursing, and tonic remedies, were what was most urgently demanded. When patients in the depressed state just described happen to be attacked by hospital gangrene, the morbid action, the intense pain, and the loss of appetite with which it is usually accompanied, quickly reduce them to a still lower ebb; and it requires the greatest skill and the most unremitting attention to support them through the terrible ordeal to which they are then subjected. It will sometimes become an anxious matter for a surgeon to decide, when life seems in danger from increasing gangrene taking place in a wounded limb, whether amputation may not hold out a better prospect of saving the patient's life than allowing the strain on the powers of his constitution to continue. Too frequently, however, when the question is discussed, the state of the patient has become such as to prevent any reasonable prospect of success from the operation.

Treatment of pyæmia after gunshot wounds.—From all that was said in describing this complication, and the circumstances under which it has been chiefly observed, it is obvious that preventive measures are of the first importance to wounded patients. If surgeons are still in uncertainty as to the explanation of some of the phenomena of pyæmia, at any rate a knowledge of the conditions which are generally found to lead to the production of this fatal disease enables them to become aware of the precautionary treatment which will best serve to prevent its occurrence. Strictly antiseptic treatment of the wounds concerned is forcibly indicated, because it has been proved by experience that when it is practised, pyæmia hardly ever occurs, even though it may have been previously rife in the same building when it was not followed. If a low degree of vital energy predisposes patients to

the reception of pyæmic poisoning, regular and sufficient nutritious diet, cheerful occupation of the mind, adequate clothing, and a proper amount of rest, are indicated to fortify the constitution against the effects of exposure to it. If miasmata arising from patients with suppurating wounds tend to the production of pyæmia, we can counteract their deleterious effects by taking steps to remove the emanations as fast as they arise, before they have time to become corrupt, and by separating patients with such wounds as far apart from one another as practicable. As a rule, tents in suitable weather, and next to them temporary huts, have shown themselves to be more favourable means of shelter for men under treatment for suppurating wounds than fixed solid buildings, because they admit of more thorough ventilation. Attention to all the sanitary precautions which were mentioned when describing the preventive treatment of hospital gangrene are equally necessary for averting this complication. The general excitement in time of war, the circumstances of battles, the frequent occurrence of death from causes so much more obvious to the commonest senses than that arising from the slow poison of an infected atmosphere, the sudden admission into hospitals of many wounded men together, the many demands on the time and exertions of attendants, are apt to render persons in the midst of such scenes careless as to what appear to be comparative trifles; and among the other duties of surgeons in warding off this complication, not the least important is personal observation to ascertain that the directions given on hygienic matters are really carried into execution. Surgeons can rarely rely securely on the statements of subordinates in respect to such subjects.

But when pyæmia is threatened in any given case, the special attention of the surgeon should at once be directed, firstly, to the state of the wound, and, secondly, to the patient's general condition. Both local and general treatment must be resorted to without delay.

Local treatment.—If purulent discharges have become scanty, the wound should be well fomented, warm dressings applied, and any steps taken that may appear calculated to restore free action in the suppurating surface without exciting irritation in it. On the other hand, if any collections of pus are discovered, the pus should be at once evacuated under antiseptic precautions, and steps taken to prevent future accumulations. If the wound be deeply seated, complete removal of discharges, by drainage or otherwise, should be diligently attended to. Topical applications, which may hold out a hope of improving the tone of the secreting surfaces, and neutralising any tendency to septicity in the discharges, should be employed. Weak solutions of the permanganate of potash, and also of perchloride of mercury, have appeared most beneficial in this respect. The perchloride of iron was much used

in the Italian campaign of 1859, as an application to wounds in cases where commencing signs of pyæmia were exhibited, and the effects were stated to be exceedingly satisfactory. If the suppurating wound be connected with fracture of bone in one of the limbs, and all reasonable hope of union seems to be frustrated, the question of amputation will arise. It is a question that can only be decided after a complete investigation of all the circumstances, local and general, of each particular case. As a general rule, however, if pyæmia have really commenced, and especially if it has assumed an acute character, the patient is no longer in a fit condition to be subjected to amputation. The shock of the operation will be more than he can bear with impunity; and even if the first dangers should be escaped from, a healthy reparative action cannot be anticipated. Sir James Paget has, however, pointed out in his clinical lectures that in *chronic* pyæmia, when an injured part is manifestly useless, or is a source of irritation or of exhaustion to a patient, amputation may be a very proper operation to be performed.

When joints are found to contain pus, they should be treated as pus in joints under other circumstances, especially by easy support, rest, and the maintenance of an equable temperature about them by means of cotton-wool. The fluid, if excessive, should be removed, either by the aspirator, or by incision with strict antiseptic precautions.

Constitutional treatment.—The general indications are—to remove the patient out of any building in which the septic influence may have been exerted into a fresh atmosphere, into a clean tent on suitable ground, if practicable; to try by appropriate remedies, or by exciting some of the excretory organs, to get rid of any injurious products which may exist in the blood; to support the strength of the patient to the fullest practicable extent by nutritious food in a form likely to be assimilated readily, combined with the moderate use of stimulants; and lastly, by the administration of quinine in full doses, with mineral acids. The remedies last named appear to be useful in checking the copious perspirations with which the disease is usually attended. If nervous irritability be a prominent symptom, opium is the remedy which can be most relied on for allaying it. It has been recommended to encourage pyæmic patients to take tepid drinks copiously, with a view to maintaining fulness of the vessels, so as to render them less likely to absorb matters of a noxious character into the system. Whether this injunction has any practical value is very doubtful.

Just as the perchloride of iron has been strongly praised as a local application, so also the beneficial influence of its internal administration has been highly extolled by some surgeons. It is given in rather full doses of twenty minims every three or four

hours, and is employed as an internal remedy at the same time that it is used locally.

The hyposulphites of soda and potash have been extensively tried as medicinal agents in pyæmia; but there is no sufficient evidence to prove that they have ever succeeded in controlling the constitutional symptoms, while they have often seemed to lead to derangement of the digestive organs, as well as to diarrhœa.

When visceral pyæmic abscesses have been once formed, there are no special means of helping the patient known. The general treatment which has been already mentioned should be still employed, in the hope that, by averting further noxious influence, and by supporting the patient's strength to the utmost extent practicable, time may be gained, and an opportunity for natural cure be afforded. But at this stage the disease is so generally fatal that the importance of preventive measures when similar wounds are first under treatment is all the more strongly forced upon the attention. It is the only part of the treatment on which a surgeon can reasonably place firm reliance. I cannot say that I have ever seen any remedies successful when a wounded patient has been invaded by this complication in a decided degree. I have seen patients with gunshot wounds in whom a tendency to pyæmia has existed, or in whom symptoms which have been regarded as pyæmic have shown themselves, recover under judicious treatment; but I cannot recall to mind an instance in my experience of recovery of a patient in whom pyæmia has been fully developed beyond all doubt.

Treatment of tetanus after gunshot wounds.—The diminished number of cases of tetanus relatively to the number of wounds in recent as contrasted with former wars, occurring as this diminution has done, as a rule, concurrently with better hospital arrangements and greater attention to hygienic matters, sufficiently indicates the efficiency of preventive treatment in lessening personal susceptibility to this disease. The sanitary precautions, therefore, which are acknowledged to be useful in warding off other complications of gunshot wounds, should also be regarded as one of the means of averting the probable occurrence of tetanus among wounded patients. The particulars of this preventive treatment, and the precautionary measures specially requiring attention in military hospitals, have already been referred to among the rules for the general treatment of gunshot wounds, as well as when describing the preventive treatment of some of the complications which have been already noticed.

Alternations of temperature within comparatively short intervals of time, as between day and night, especially when associated with a damp state of the atmosphere, have been so often noted as appearing to promote the occurrence of tetanus, and currents of cold air have been so frequently observed to intensify the symptoms in

patients suffering from it, that, not only as a precautionary but also as a remedial measure, the wounded patient should be carefully protected from exposure to such atmospheric vicissitudes. The maintenance of an even temperature and of a dry atmosphere in a ward in which wounded men are treated, especially if any patient showing symptoms approaching to those of tetanus is in it, is an object which every surgeon in charge of a hospital should seek to attain. If a wounded man placed in any situation which is exposed to currents of air, especially night air, complains of stiffness about the face or neck, or exhibits any signs of nerve irritation, he should be at once removed to an apartment where he can be fully protected from such influences.

Curative treatment.—When symptoms of tetanic irritation become manifest, the surgeon's attention must be given to the state of the wound, and also to the general condition of the patient, as in other complications. Efforts should be made, without any delay, to remove the irritation at its source; for there is reason to believe that the earlier this can be effected, the greater will be the chance of arresting the advance of the diseased action.

Some of the examples mentioned in the general remarks on this affection have afforded evidence, on examination after death, tending to show that the lodgment of foreign bodies, such as pieces of cloth and fragments of projectiles, has been the immediate origin of the evil; while other examples have seemed to prove that the removal of such sources of irritation may occasionally stop the progress of the malady, even after tetanic spasms commenced. The wound, therefore, if it be suppurating, should be cautiously and thoroughly examined with a view to remove any extraneous substances that may be lodged in it. If it be deep and tortuous, it should be well irrigated with some warm antiseptic lotion, but without roughness; the object being to flush away any pieces or fibres of cloth that may have been caught and be lying in some part of the track. As soon as the wound is cleared of all foreign bodies, it may be bathed with some warm anodyne fomentations, and lint, moistened with an opiate solution and covered by oiled silk, may be left on it as a dressing. The guiding principles in treating the wound at this stage should be to maintain an equable temperature, to ensure the part in which it is situated being in as easy a posture as practicable, and to apply only such dressings as shall keep it aseptic and at the same time exert a soothing influence. No tight pressure of any kind should be permitted near the wound. If there be any constricting bands of tissue about the wound, these should be divided before the dressings are applied, so that all the parts may be kept as free from tightness and restraint as possible. The importance of preserving an even temperature about the patient has been referred to elsewhere, and the advantage of maintaining an equable

temperature of the wound itself has just been mentioned. Dr. Chenu has stated that in the Italian war the plentiful use of tow for enveloping wounded parts which were painful, and sensitive to the impression of cold at night-time, though a simple matter, proved itself a means of help which ought not to be lightly rejected. 'Under the influence of tow so applied,' Dr. Chenu remarks, 'and of opiate dressings, we have seen commencing symptoms of tetanus rapidly disappear.'[39] Various kinds of antiseptic cotton-wool are now available which will better accomplish this purpose.

In the post-mortem examination of a stump in a case where tetanus carried off a young officer whose arm had been amputated for a gunshot wound after the battle of Eylau, Baron Larrey found the median nerve included in the ligature of an artery; and this circumstance, together with other like observations, led him to think that the inclusion of nerves might be a frequent cause of tetanus after amputation necessitated by such injuries. This distinguished French surgeon relates that, turning this experience to useful account, he averted in several instances, on the first appearance of symptoms of tetanus, the full development of the disease by passing a grooved director carefully between the artery and the ligature, and dividing the latter. In all similar cases, therefore, it will be prudent for a surgeon to ascertain that no nerve has been accidentally included in a ligature.

The complete division of small branches of nerves which have been lacerated in gunshot wounds has in some rare instances seemed to arrest the disease after trismus and symptoms of the approach of general tetanus had shown themselves; but in many other cases the plan has totally failed. Equally, amputation and re-amputation have been tried by military surgeons where tetanus has occurred after gunshot wounds in the extremities; but whenever the disease has assumed an acute form, the operation seems to have invariably proved unsuccessful; in some instances, when the disease has been of a milder description, the operation has succeeded. Amputation was resorted to in twenty-nine instances during the United States civil war, and in ten of these recoveries were obtained. But it is mentioned that in these cases only incipient tetanic symptoms had appeared. Other remedies of a less severe character have succeeded in similar cases.

The performance of amputation as a curative measure cannot therefore be recommended when tetanus has fully established itself. It is now manifestly a constitutional and general disease, the nervous centres are fully involved in it, and there can be no reasonable ground for expecting that the local amputation can put a stop to it. On the other hand, if the disease present itself only in a limited degree, in simple trismus, or trismus only associated with stiffness of some of the neighbouring muscles, it does not

appear justifiable to resort to a large amputation for its cure; milder remedies may be as successful as this serious operation; but if the state of a wound in one of the extremities be such as of itself partly to justify the amputation, then the hope of removing the source of irritation, and putting a stop to the commencing tetanic symptoms, will render the operation a justifiable proceeding if the patient be strong enough to bear it. Dr. Chenu has recorded three instances in which the operation of amputation above the parts wounded was performed during the Italian war in order to arrest tetanus, but without obtaining even an amelioration of the symptoms.[40] It is recorded, however, that during the United States war two cases of recovery from tetanus took place after amputation of the wounded part, and that in these cases the 'symptoms were very grave.'

Constitutional treatment.—The early administration of an active purgative, such as a dose of calomel or croton oil, which can be given even if there is some difficulty in swallowing, or the exhibition of a full turpentine or other enema, to relieve the lower bowel of any accumulations, is generally an advisable proceeding.

The special remedies that have been tried empirically in tetanus have been most numerous, and they have been administered in an endless variety of doses. Opium administered internally, hypodermically, or smoked, camphor, chloral, strychnia, cannabis Indica, Calabar bean, alcoholic stimulants, chloroform, digitalis, belladonna, aconite, atropine, mercury by the mouth and friction to salivation, quinine, chloride of barium, may be mentioned as having been among the number, but many others have been used. The very variety serves to prove how little reliable any one of them has been found to be. Surgical proceedings, such as the application of irritants and cupping along the spine, ice along the spine with a view to relieving congestion of the cord, have been made use of, but have generally failed to make any impression on the disease. Venesection was employed to a considerable extent during the Italian campaign, but was not productive of benefit.

A very great variety of remedies was tried in the treatment of the 500 cases of tetanus that followed wounds and injuries during the United States civil war. As many as sixty different kinds of internal and external remedial agents are mentioned in the surgical history of the war. But the history states it is not possible to say how far one or other of them was of any avail. The recoveries occurred in the slighter forms of the disease or in those in which it took on a chronic course. All remedies failed in cases in which the disease was fully developed.[41]

The inhalation of chloroform, although it does not appear to have affected the ultimate result of the disease, according to general testimony, has often been serviceable in causing a temporary mitigation of the violence of the spasmodic contractions. Dr.

Bima, Divisional Surgeon in the Sardinian army, has mentioned that in some cases of tetanus observed by him during the Italian campaign of 1859, the wounded men urgently begged for a repetition of the chloroform when once they had been subjected to its effects.[42] Unfortunately, as soon as the patients have ceased to be under the influence of the anæsthetic, the muscular stiffness and then the spasms have generally returned.

Curara was employed as a remedy in some cases during the Italian war of 1859. It was brought into special notice by a successful result which followed its administration by M. Vella of Turin, in a case of acute tetanus after a bullet wound of the foot, in which one of the metatarsal bones was broken. The wounded man arrived at Turin on June the 7th. Commencing trismus, with difficult and somewhat painful deglutition, showed itself ten days afterwards. The next morning trismus was complete, in the course of the day tetanus became general, and in the evening the tetanic spasms were violent and very painful. A strong solution of curara was at once applied to the wound, and a calming effect speedily produced. After a short time, as the absorbing power of the surface of the wound seemed to be lessened, small blisters were raised in succession, and these were dressed with the curara. According to the description of Dr. Isnard, who watched the case, the tetanic spasms were suspended after each dressing. The wound was dressed by the curara five or six times in the twenty-four hours, and the dressing was each time followed by calm sleep. Under this treatment the spasms gradually diminished in intensity, the patient was enabled to take nourishment, and in about a month from the commencement of the attack, all the tetanic symptoms had completely disappeared. The wounded man left shortly afterwards for France. The curara had been tried in three cases previously; but although the calming effects at each application were strongly marked, as soon as the action of the medicine was expended the tetanic spasms returned with the same violence, and only disappeared for a time when the curara was again applied. Of the cases of tetanus which occurred among Austrian, French, and Sardinian soldiers in the war of 1859 that are tabulated by Dr. Demme, the only case noted as having been treated by curara is the case of M. Vella before mentioned.[43] Woorara is named among the remedies employed in the United States war, but it is not noted that any beneficial effects attended its use. The production of copious and prolonged diaphoresis by hot air or vapour baths and warm drinks has occasionally afforded much relief to patients, and in some instances has appeared to assist in effecting a cure. Dr. Reeb has recorded two cases of recovery at Strasburg during the late Franco-German war, in which vapour baths, combined with hypodermic injections of morphia and the administration of

stimulants, were the remedies employed. But in these two cases the disease was of a chronic character, was confined to trismus, stiffness of neck, and some difficulty in swallowing, neither the limbs nor the trunk being invaded by spasms; while in ten other wounded patients who were subjects of tetanus at Strasbourg the same remedies were employed, but all the cases terminated fatally.[44] Three additional successes during this war are reported by Dr. Chenu, and in these instances the production of copious transpiration, together with the administration of chloral, were the remedies employed. They also appear to have taken place in patients in whom the disease did not assume a violent or general character.

Attention has recently been called to the use of nitrite of amyl in arresting tetanus. It seems to have been given in several cases with successful results. In three the nitrite of amyl was combined with other remedies, so that the value of this drug could not be distinctly determined; but in one case, in which acute tetanus followed extensive burns of the body and extremities by hot iron blown against the patient from a foundry, the nitrite of amyl was given alone and the patient ultimately recovered. The case is related at full length in the *Philadelphia Medical Times*, of June the 12th, 1875, by Dr. William S. Forbes. The tetanic symptoms began on the fourth day after the injuries, and advanced to general spasm, especially opisthotonos, of a severe description. The use of the drug was begun on the evening of the sixth day, forty hours after the first signs had shown themselves. It was given in doses of three drops, subsequently increased to five drops, inhaled twice daily. When omitted for two days, the eighteenth to the twentieth of the disease, the man grew rapidly worse; while, on being again used, the patient experienced speedy relief, and from that time progressed steadily to complete recovery. The amyl was discontinued on the forty-sixth day after the first dose was given. The patient had inhaled, altogether, one ounce of the drug.

The records of military observations of tetanus have unhappily tended to confirm the general experience regarding it in civil practice. In its subacute form there are occasional recoveries under various kinds of treatment; in its acute form, when it occurs early after gunshot wounds or amputation consequent on them, and when the spasms spread from one set of muscles to another in rapid succession, no kind of treatment can be said to have proved itself of special avail. Even in instances followed by recovery, it has been difficult to determine what part in the cure the remedies administered have had. The cure may have been equally attributable to subsidence of irritation from natural causes, so frequently have the same remedies, which appeared to be beneficial in the successful instances, been tried in others and followed by failure.

Treatment of erysipelas after gunshot injuries.—The remarks which have been made on the preventive treatment of hospital gangrene; on the importance of removing the subject of it from the place where the disease has been contracted, and of isolating him from other patients; of removing other wounded patients who are free from the complication into a fresh atmosphere in tents or elsewhere, especially men who are necessarily confined to bed from the nature of their wounds, and are therefore constantly breathing the air of a single apartment; the description of the hygienic measures to be adopted, and the attention to be given to other means of preventing the spread of the hospital gangrene by accidental inoculation or otherwise, are all equally applicable to the complication now under notice. No patient who has become the subject of erysipelas should be allowed to continue in the same tent or ward with other wounded men. If it be permitted, the spread of the disease to the other patients may be regarded as almost certain.

In treating erysipelatous patients, a little consideration of the circumstances under which the disease has too often made its appearance in military practice will suffice to show the necessity for taking precautions to prevent aggravation of its character by allowing the atmosphere around the patients to become contaminated or stagnant. Erysipelatous patients can be best treated in tents; for in tents, with good management, there can be ensured the most thorough ventilation, almost the same purity of atmosphere as outside, and at the same time all needful protection from partial currents of air and changes of weather. A constant supply of fresh and pure air is as necessary in the treatment of the disease as it is for its prevention.

Wounded men convalescing from an attack of erysipelas should be placed apart from men recently attacked by the disease. It has been noticed that where this rule has not been enforced, relapses have occurred among the convalescents.

Simple cutaneous and phlegmonous erysipelas of a mild character, when hygienic necessities are duly attended to, requires but very slight treatment, either constitutional or local. There seems to be an inherent disposition in these milder forms to pass through their successive stages without exciting much constitutional disturbance or local mischievous consequences. A suppurating wound in a healing condition in a soldier in a good state of general health may chance to become the centre of a moderate erysipelatous attack although antiseptically dressed; but if the patient be surrounded by a pure atmosphere, the administration of a simple purgative, a temporary restriction of diet, and the local application of some slight soothing and protective remedies, such as powdering the surface with finely levigated chalk, starch, or ordinary wheat flour, and maintaining an equable temperature by enveloping the

parts concerned in some antiseptic cotton-wool, will usually soon cause the activity and spreading tendency of the disease to cease. In a few days the redness will disappear, and a desquamative action ensue without further trouble.

But when large and lacerated wounds are attacked by erysipelas, especially if the disease be endemic at the time, or the wounded men have been previously depressed by much fatigue and exposure, or their constitutions deteriorated by the unsanitary influences of ill-conditioned hospitalisation, the disease is apt to assume a more virulent character. Great care and active measures now become essential to restrain it within bounds, and to ward off the threatened destructive consequences to the areolar and other tissues in the neighbourhood of the wound, as well as to guard the patient against the effects of the great prostration by which the attack will almost certainly be followed.

The treatment of erysipelas naturally divides itself into constitutional and local treatment, as it does in other allied diseases.

Constitutional treatment.—In the treatment of almost all soldiers whose wounds are attacked by erysipelas, it is well to commence the constitutional treatment by administering an active calomel purgative. Some surgeons advocate the employment of an emetic at the outset, and if the frame of the patient be vigorous, and the action of the medicine be accompanied by copious draughts of warm water, so as to clear the stomach completely and bring on profuse diaphoresis, the effect will probably be very beneficial; but otherwise, it may increase depression, and do harm.

For the succeeding two or three days no better medicine can be given to the patient than a saline mixture, combined with a mineral acid, in repeated doses sufficient to maintain a moderate action of the bowels. If the fever be very high, diaphoretics should be administered, and the use of the mineral acids delayed until a later date. These remedies should be followed by some of the preparations of iron, which seem to exert a special influence on the disease. The tincture of the sesquichloride in doses of 25 or 30 minims in a little water every three or four hours is one of the most usual and convenient forms of the remedy in military hospitals. It sometimes produces a very marked beneficial effect: diminishing the intensity of the local symptoms, and seeming to prevent the spread of the disorder as soon as a few doses have been taken. Other salts of iron are occasionally given.

The patient's strength should be sustained throughout by abundance of nutrient support in the form of beef essence, milk, and any light articles of food he may feel inclined to take. In some cases of erysipelas occurring in chronic wounds, the very fact of the attack is indicative of a susceptibility to the disease from a weakened state of constitution, while the erysipelas itself

acts as a cause of additional prostration. The support of the strength of the patient then becomes a matter of vital importance. His habits, and, to some extent, his fancies, must be taken into consideration when determining the nourishment most appropriate to his case: as a rule, only very light articles of diet can be tolerated while the attack lasts, and those only in very limited quantities at a time. When thirst is troublesome, it may be allayed with advantage by some of the acidulated drinks, especially the lime and lemon juice drinks. The administration of ipecacuanha wine in water in very small doses of four or five drops at regular intervals of one or two hours—not in quantity enough to produce any nauseating or depressing effect—has sometimes seemed to afford the best means of lessening thirst, at the same time that it has assisted in allaying general irritation, and acted favourably on the skin.

Narcotic remedies do not generally seem to be advantageous in the earlier stages of erysipelas, and must always be administered with great caution, especially if any signs of cerebral excitement are present. When erysipelas attacks wounds of the face or head, the patient usually exhibits much torpor and drowsiness, and the disease in this situation is attended with great danger in consequence of the tendency to cerebral congestion. Opiate remedies would manifestly be out of place under such circumstances. But in other situations—in wounds of the extremities—and when there is much nervous excitement with prostration, narcotic remedies should be given, but still with great caution. A tendency to cerebral disturbance seems to accompany the disease independently of its locality. After evacuation of abscesses, and when sloughs are being discharged, when there is much debility, constitutional irritation, and sleeplessness, opium in some of its forms is often of the greatest value as a sedative, and can usually be administered without any ill results.

In no condition of wounds does the advantage of administering stimulants seem to be so manifest as it is in gunshot wounds, which have been attacked by erysipelas, attended with diffuse cellular inflammation. Wine or alcohol in any of its ordinary forms, especially if the patient has been in the habit of drinking spirits, may be given in all such cases with advantage; they 'keep up the patient,' in ordinary language, and, when judiciously administered, enable a wounded man to fight against the prostrating effects of the disease, who might otherwise succumb to its influence.

Local treatment.—The indications for treatment locally are to relieve the vascular excitement and tension of the inflamed tissues; to prevent the spread of the disorder to the adjoining parts which are still free from it; and, when abscesses or mortification of tissue have taken place, to afford such speedy surgical relief as will serve to limit the morbid action within the narrowest

bounds, and to prevent the further ill effects which purulent or other collections are likely to lead to, if they are permitted to remain pent up beneath the fascial coverings. Local applications should be only regarded as subsidiary to the remedies employed in the constitutional and hygienic treatment.

The state of the wound should be first considered. If it be a shell wound with considerable laceration and contusion, or a superficial rasing or tunnelled wound by a small projectile—the most likely kinds of wounds to be attacked by erysipelas—fomentations or injections of warm permanganate of potash lotion will soothe the parts, help to remove any foreign substances that may be acting as sources of irritation to them, and thus smooth the way for a better action of the remedies which are applied to the adjoining inflamed parts.

To relieve the vascular congestion and tension of the integuments some surgeons apply fomentations and envelopes of linseed-meal poultices to the inflamed parts; others resort to depletion by leeches, by cupping, repeated punctures, numerous short incisions, or by two or three prolonged incisions, through the inflamed parts. All agree that cold applications are objectionable, on account of their tendency to lower the vital power of resistance in the affected parts, especially in debilitated patients; and because, though they may lessen the superficial excitement, the deeper tissues are rendered more liable to become involved in the morbid action. I do not think I have ever observed beneficial results from the use of hot fomentations or poultices to the inflamed skin in the early stages of erysipelas. The fomentations do not seem to afford the relief that they often give in simple inflammation, nor are they followed by that relaxation of the vessels or diminution of the tension which might be expected from them. In erysipelas of a phlegmonous character occurring in the extremities, when the action appears to be on the increase and the tension becomes more and more marked, depletion affords the most speedy and surest relief; and the manner of effecting it, which has appeared to me to be attended with the least inconvenience, has been the plan introduced by Hutchison,[45] of repeated longitudinal incisions through the integuments about 1½ inches in length, from 2 to 4 inches apart, and varying in number according to the degree of tenseness of the inflamed parts, and the extent of surface occupied by the disease. Fomentations after the incisions, to promote the escape of a certain amount of blood and serum, add to the local relief and give ease to the patient. The amount of bleeding which is allowed to take place must be adapted to the patient's general condition of strength. When the bleeding has been controlled, lint wetted with an anodyne lotion rendered lukewarm, as the subacetate of lead and opium lotion, or with sublimate lotion, is laid over the inflamed part,

and the whole is then enveloped in a thick covering of antiseptic cotton-wool, lightly supported by a bandage, and placed in an appropriate position according to the situation of the part concerned.

If there be reason to suppose that the sub-fascial tissues are involved in the morbid action, and, still more so, if there be reason for believing that suppurative action has commenced, the incisions must be deeper. The fascia itself, and the connective tissue beneath, must be freely incised, with a view to afford more complete relief to the local tension, to reduce the pressure caused by infiltration of the subjacent structures, to relieve pain, to evacuate any purulent collection that may have formed, and to prevent as far as possible sloughing degradation of the connective tissue and perhaps gangrene of the surface. Excess of bleeding must be checked by position, the temporary application of hæmostatic substances, with moderate pressure. When the bleeding has subsided, bathing with moderately warm antiseptic lotions and light pressure may be employed with advantage to assist in clearing away purulent fluids or decayed cellular tissue from the deeper situations. The Condy's fluid before mentioned appears to be one of the least irritating lotions, and also to be very suitable for this purpose. It may frequently be necessary to remove shreds of sloughy areolar tissue by the forceps. Constitutional support and careful nursing are in this stage of the disease of vital importance.

Several substances applied to the erysipelatous skin, or to the healthy skin adjoining, have a controlling action on the character of the inflammation, or exert an influence in arresting its onward progress, in the milder forms of the disease. The application of solid nitrate of silver, moistened, to the healthy skin outside the erysipelatous inflammation, so as to form a complete black band around it, will sometimes stop its further spread. Or if the disease involve the whole circumference of a limb, a similar band may be applied completely around it, above the seat of the erysipelatous inflammation. Care must be taken that the limiting cordon is in each case quite complete. Dr. Chenu mentions that at one of the hospitals at Metz, during the Franco-German war, the spread of erysipelas in the extremities was always arrested by the application of a narrow slip of blistering plaister, arranged so as to entirely surround the limb. The blister opposed a barrier which the inflammation did not succeed in passing.[46] Blisters have sometimes been applied to the inflamed surface itself, especially in cases in which the inflammation has extended deeply, and in erysipelas of the phlegmonous kind, and have been said to be useful. They are obviously remedies which must require caution in their use; for their action, in cases attended with marked debility, might be readily followed by gangrene of the superficial parts to which they had been applied.

Sometimes a strong solution of nitrate of silver, about a drachm to an ounce of distilled water, has been applied over the whole erysipelatous surface and a limited portion of the healthy skin beyond it. The concentrated aqueous solution of perchloride of iron, tincture of iodine, a coating of collodion, have been also employed in a similar way, and in some instances have appeared to put a check to the disorder. During the United States civil war, a solution of bromine was used as a topical remedy in erysipelas, with, as it was said, very good effects. About half a drachm was mixed with an ounce of water and applied to the erysipelatous surface. But it is only in the milder forms of erysipelas that any reliance can be placed on such means of arresting the progress of the disorder, and only then in conjunction with constitutional treatment and under favourable hygienic circumstances.

Treatment of traumatic delirium after gunshot injuries.—The treatment of this distressing complication of gunshot injuries, and of surgical operations consequent on them, is always very difficult, and, unhappily, too often fruitless. Much care and judgment are required in the management of cases of this disorder. A correct appreciation of the causes which have conduced to the attack in each instance will give the fairest prospect of a successful issue by indicating the most appropriate treatment to be adopted.

If the attack be mainly due to the shock of the injury to which the soldier has been subjected, or to the loss of blood attending it, acting on a constitution which has been undermined by previous habits of intemperance, or by a recent indulgence in alcoholic stimulants, it must be treated on the same principles as an outbreak of delirium tremens. It is in all essential particulars an attack of this disease on a frame constitutionally prepared for it; the shock resulting from the patient's wound merely acting as the exciting cause.

The surgeon will probably experience a difficulty in ascertaining the state of the patient's excretions, but it will always be right in the first instance to administer a purgative, taking care that it is not of too depressing a character. Probably the most convenient, and the most efficient in such a case, is to place five grains of calomel on the tongue, giving the patient a little of the stimulant to which he has been accustomed to induce him to swallow it. Twenty-five or thirty drops of laudanum may be added to the draught to lessen the disturbing action of the calomel, and as a commencement of the sedative treatment which is chiefly indicated. A saline draught, with the addition of sulphuric or some other mineral acid, and a moderate dose of the tincture of opium, may now be given every two or three hours, until the bowels are acted upon, when the saline should be discontinued and the acid and

opiate treatment persevered in. If there are difficulties in administering the opiate in draughts, the hypodermic injection of morphia may be used instead. Sleep is the object to be attained, and all that can be done to gain this end, in addition to the exhibition of the medicines just named, should be done. Light should be subdued, and all sources of disturbance, such as noise, bustling movements, and loud talking, be controlled as far as practicable. The action of the opiate should be closely watched, and if, when it has been given in amount up to the limit that would be safe for an adult in an ordinary state of health, it does not appear to be quieting the delirium, or to be inducing sleep, it ought to be discontinued and other remedies tried. Among these may be mentioned the hydrate of chloral, hyoscyamus, and cannabis Indica, as the most efficient substitutes for opium, the first named being the remedy the most to be relied upon. Neither the digitalis nor the bromide of potassium treatment of delirium tremens is applicable to cases in which the attack has been induced by the shock or collapse succeeding to a severe gunshot injury.

Important questions arise as to the best mode of maintaining the strength of the patient, and the extent to which stimulants can be given with advantage. It is hardly possible to lay down any precise rules on these subjects; the judgment of the surgeon must decide such points according to the habits and condition of each patient under his care. Of the vital necessity for nutrient support there can be no doubt. The disease at the outset is one of debility; it is probable that for some time previously to the attack the digestive organs have been greatly deranged; the wound and loss of blood have lowered such previous strength as the patient had; wakefulness, delirious excitement, and muscular exertions tax his vital powers to an inordinate extent; other debilitating influences, if the patient survive, are to be provided for; so that, on all sides, the necessity for nutrient support is urgently indicated. It is useless to try to give nourishment in a solid form, and, even if concentrated in a liquid form, there may be almost insuperable difficulty in getting it swallowed. If the patient will swallow food, the addition of cayenne or other pepper in considerable quantity will generally help to ensure its digestion. Nourishment is more likely to be taken if combined with stimulants, and probably also more likely to be assimilated; and the tact and thoughtfulness of the medical attendant will be tasked in determining the particular form in which it will be most acceptable. Attempts to administer nourishment by enemata present special difficulties in such cases. The exhibition of stimulants in moderate quantities, especially those which the patient has been accustomed to take, is a necessary proceeding; but this part of the treatment should only be regarded as a means

of maintaining the patient until the impediments to the more natural process of replenishing bodily waste, and supporting strength, by food and rest, can be removed. The use of stimulants, therefore, should be gradually lessened in proportion as a return to health shows itself.

If the excessive use of tobacco prior to the gunshot injury be supposed to have favoured the occurrence of nervous delirium, the disorder must be treated on the same principles as when it has arisen from excessive alcoholic stimulation. The best sedative in this case will probably be the tobacco itself, and as the patient is not likely to be in a condition to resume its use in the ordinary way, attempts may be made to administer it as an injection. If it can be accomplished, it should be done very cautiously, as in this form the drug will often produce an amount of depression far exceeding its usual effect when smoked.

Whatever the source of the delirious excitement, one of the greatest difficulties met with in the treatment of the patient is that of preventing him from doing harm to himself, either to his person generally or to his wound. A surgeon may be easily thrown off his guard, either by a temporary lull in the patient's excitement, by his manner, or by his remarks. But the subject of this complication must always be unceasingly watched. His wound, or stump, should be protected in the best manner practicable, but should be exposed to view; for if it be out of sight the patient will not improbably contrive to remove the dressings or splints that have been applied to it. In instances where the excitement prompts the patient to injury of persons near him, or leads to a suicidal tendency, it is rarely safe to trust to the restraint of attendants. The patient must be confined by the strait waistcoat or other similar means. It is a form of restraint that should never be employed when it can prudently be avoided, for it rarely fails to add to the irritation of the patient, and to increased struggling and exertion; but when the patient's own safety, as well as that of his attendants, depend upon unceasing restriction, it is the only means that can be employed with security. Great care must always be taken in employing it, that, while secure, it exerts no local pressure likely to give pain, or to impede freedom of circulation or respiration.

Some assistance in treating the disorder may be obtained by removing the patient's hair and applying cold lotions to the head. The German head-net is one of the best means of retaining wetted applications to the head under the circumstances of patients in a state of delirium. Is is questionable whether any advantage is gained by the application of blisters to the nape of the neck, which are sometimes recommended.

The two important indications of treatment to be borne in mind in all cases are, first, to lessen, and, if possible, altogether

to allay the morbid excitement of the nervous system; and efforts must be made to attain this end through the medium of sleep. If only sleep can be induced, there will be immediate relief of the urgent symptoms; and if it can be maintained to a sufficient amount, a cure of the complication will in all probability be effected. The second important indication is to maintain strength by appropriate nourishment during the attack; and the more prostrated the condition of the patient, whether by loss of blood or any other cause, the more vitally important does this indication become.

A knowledge of the usual causes of the state of nervous irritability which is apt to terminate in traumatic delirium—and they have been already mentioned in describing the complication itself—sufficiently point out the preventive measures to be taken to avert its occurrence. Much may be done towards lessening the nervous irritability consequent on a wound by judicious management at the first opportunity after its occurrence. Each case will have its own special features, and must be treated accordingly. In some persons moral influence is most required. Kindly and encouraging arguments judiciously enforced will sometimes suffice to allay the irritability of a patient, in whom, under rough usage or simple neglect, aggravated by the debilitating effects of his injury, it will go on increasing until it passes the limits of control. In some instances, the prevention of traumatic delirium will depend upon early attention to the state of collapse into which the injury has thrown the patient; in others, upon the care with which a patient is raised from the state of general debility into which he has been thrown by the exhausting effects of hæmorrhage. It is especially during the early condition of patients, prostrated by their wounds on the one hand and nervously excited on the other, that careful attention, tact derived from experience, and judicious treatment on the part of the surgeon, are of the highest value, for it is during this period that they can be employed with the most effectual results in warding off this serious complication of such injuries.

Treatment of larvæ in gunshot wounds.—When circumstances render wounds liable to become infested by the larvæ of flies, the treatment to be adopted divides itself into two parts: firstly, prevention of the access of flies to them; and secondly, treatment to rid the wounds of any larvæ which may have become developed in them.

Modern antiseptic dressings, with ordinary cleanliness and care, usually suffice to prevent the deposition of ova in wounds, although the patients are surrounded by flies in countless numbers. Close attention must be given to ward off the insects, or they will certainly at some unobserved moment find access to the sore surfaces. It must be remembered that the ova themselves, when

deposited, are not visible. During the Crimean war, cotton gauze net was issued for use in the hospital tents and huts as a protection against flies. It was laid over the parts of the body in which the wounds were situated, whenever these were exposed in order to be cleansed or dressed; and as the flies, even when prevented from reaching the wounds themselves, irritate patients by their habit of hovering in multitudes about them, the net was also used for covering the faces of the wounded men to enable them to get peace and rest. Linen moistened with a weak solution of chlorinated soda or zinc, or with a solution of creosote in water, laid loosely over the dressings, was found to be useful as a protection. Dr. Brougham, whose vivid account of the distressing annoyance caused by the multiplication of flies and maggots in the hospitals during the siege of Delhi will not be forgotten by those who have read it, states that he found the application of lotions containing oil of turpentine and camphor the most efficacious treatment against them.

When larvæ burrow, and they will sometimes do so in hot climates to a considerable distance, injections must be employed. These will cause them to approach the aperture of the wound, whence they must be removed by the aid of a forceps. On one occasion I had under my care in Bengal a contused wound of the head. It was progressing favourably, when at one of the morning visits I discovered to my astonishment that the scalp was burrowed in all directions by larvæ. The wound had been carefully dressed, and my native dressers were all that I could desire them to be. The accidental appearance of one of the larvæ in the wound led to the discovery of the state of the scalp. No more irritation had attended their presence than the injury to the head itself had seemed to account for. The removal of the nuisance was tedious, and recovery was only attained by diligent extraction of the larvæ singly, and by injections with weak solutions of creosote. In the West Indies, tobacco-water, under the name of Chigoe-water, from its employment in destroying chigoes after they have entered the skin, was used as a remedy in my time for ridding wounds of maggots. It is not improbable that flies sometimes find their opportunities of getting at wounds during the night-time, owing to the disturbance of dressings by movements of patients during their sleep. It becomes important, therefore, to take especial care at the evening visit that the dressings and protective coverings are well secured, so that access of the flies to them may be prevented during the interval which will elapse before the visit in the morning. Happily for surgeons whose duties are limited to dealing with wounds in the hospitals of temperate climates, the treatment of this repulsive complication can scarcely ever concern them.

SECTION IX

ADMINISTRATIVE ARRANGEMENTS FOR THE CARE AND TREATMENT OF WOUNDED SOLDIERS IN TIME OF WAR

Preliminary remarks.—The means which are provided for the care and treatment of the wounded men of an army engaged in active military operations, together with the system authorised for applying them—whether on the field of action, in the hospitals, or while the wounded are in course of removal from the one to the other—must always have so considerable an influence on the ultimate results of the injuries which the wounded men have received, that a description of these matters could not be omitted from this work without neglecting an important part of the subject of the general treatment of gunshot injuries as they occur in time of war. Whatever amount of knowledge has been gained of the proper course to be pursued in the management of gunshot injuries individually, it will all be of little avail in practice, especially when this practice has to be conducted on a large scale, if the surgeons have not at their disposal suitable articles for the due protection and treatment, as well as for the care and nursing of their patients. The truth of this statement forces itself most strongly upon the attention when the circumstances in which troops are usually placed during the progress of a campaign are considered. It is one of the functions of the Army Medical Department to study these subjects, and to make recommendations on them to the War Department of the Government, especially as to the kinds and numbers of hospital establishments necessary to be provided on the outbreak of war; while it is the province of the supreme authorities to determine how far the recommendations are to be complied with. Some of the questions that arise in considering these subjects are by no means easy of solution; so many and so various are the circumstances which exert an influence on the decisions that may be formed regarding them.

On attempting to review the arrangements which have to be made in order to carry on the business of the medical department of an army in time of war efficiently, it soon becomes evident that the subject is as complex as it is important. Its complexity makes

itself apparent when the varied kinds of military operations adopted for purposes of attack and defence are remembered; for, in regard to nearly all these undertakings, forethought has to be devoted, and, in many of them, special provision has to be made by the Army Medical Department in order that the health of the men composing the army may be preserved, and the sick and wounded duly cared for. Its importance is rendered obvious on studying the histories of campaigns; by observing how much the welfare and confidence of the troops, the maintenance of the strength of armies, the prevention of delays, and the consequent facilities afforded to commanders for carrying out their strategical designs—not to mention ultimate economy as regards expenditure—have depended upon there being a sufficiency of medical aid on the spot, upon the equipment and essential hospital supplies being adequate in amount, and ready whenever needed for meeting the necessities of the sick and wounded, and also on the plan of hospital administration being well contrived and systematically executed.

The provisional arrangements which particularly influence the results of the treatment of gunshot injuries in time of war are most conveniently divided for purposes of study into two principal parts; one being that of *organisation and administration*, the other that of *equipment*. Of these two divisions the former is certainly the more important. According to the plan on which the Field Medical Service is organised, and to the intelligence and energy with which it is carried out and adapted to the varying contingencies of war, so will be the degree in which the hospital staff, whatever its numbers, and the equipment, whatever its amount, are turned to useful account. When the organisation is good and well administered, the services of all the functionaries included on the establishment will be utilised, and they and the articles of equipment will be in the places where they are most required; when the organisation is bad or badly administered, a considerable amount of personal capacity will be misdirected and probably wasted, while many needful things which have been provided will be absent from the places where they are urgently wanted. Under the first-named condition, when an engagement occurs, the wounded will be systematically attended to, have their wounds dressed, and be moved to their appointed hospitals with all the promptitude, regularity, and care that the surgeons and means at command render possible; under the second, there will be confusion, needless delay, and, as an inevitable consequence, an increase of suffering, prolonged hospital treatment, and, ultimately, very probably a higher rate of invaliding and mortality among the sufferers. Even though the hospital staff may be comparatively limited in number, and the supply of transport and other hospital equipment only moderate in amount, yet, if well organised and handled, they may enable the requirements

of the wounded to be more quickly and efficiently met, than a far more numerous staff, and more abundant stores and transport, under opposite conditions. Substitutes, more or less perfect, can be found for many articles of equipment, while extra zeal and devotion may make up for deficiencies in the numbers of the medical or subordinate staff; but nothing can prevent the evils which follow in the wake of imperfect organisation and careless administration. The quality of the administrative arrangements of the medical department of an army is quite as important, indeed, under some circumstances, may be even more so, than the quality of the executive medical service. The amount of professional knowledge of the medical officers, and of their practical expertness in the performance of surgical operations, will doubtless determine the results of many individual wounds and injuries; but it must depend upon the general administration how quickly, and under what conditions, this knowledge can be applied. Thus, though the surgeons may possess all the skill and dexterity which will enable them to decide exactly what ought to be done in each particular wound and injury that may fall under their care, and to do it, yet their science and ability may be rendered comparatively fruitless by an ill-advised or ill-conducted system of administration. It is from this cause that army medical officers have come to be employed in two capacities, administrative and executive. The former officers are required to see that the authorised plan of dealing with the wounded is carried into effect, to settle the various questions and to remove the difficulties which may arise while it is in process of execution, and, in short, to take the necessary steps for ensuring that all the parts of the field medical system work regularly and smoothly in concert. The right performance of these functions requires much previous acquaintance with military arrangements, particular tact and energy, and an amount of supervision which can only be given by an almost exclusive devotion of time and attention to the duty.

A description of the arrangements which are necessary for preserving the general health of troops in the field, and of the steps to be taken for their practical execution, although they indirectly influence the effects of injuries when they occur, does not belong to this work: they are treated upon in books on army hygiene. Only those matters can be noticed here which have a special bearing on the wants of *wounded* men. These will be considered under the four following heads, viz.: (1) Hospital organisation; (2) Hospital administration; (3) Hospital equipment; and (4) Sick-transport equipment.

CHAPTER I

ARMY HOSPITAL ORGANISATION

Organisation in peace-time relatively to time of war.—As an army is only maintained for purposes of war, either defensive or offensive, it is obvious that the organisation of its several parts in time of peace should accord as far as practicable with the organisation which will be necessary when war occurs. This applies to the medical equally with all other parts of the army. The constitution of the hospital staff, medical and subordinate; the system on which the hospital duties are conducted, their distribution and direction; the transport arrangements; the forms of the transport vehicles and of the hospital equipment, should all have reference to the necessities of time of war. The staff will thus be trained and accustomed to the duties which they will have to perform in the course of a campaign, often under very difficult circumstances; and they will become familiar with the equipment which will be at their disposal for use in the field. Many improvements will suggest themselves from the experience which may be thus gained; and, in the end, the various demands which are made on the medical service with very special urgency in time of war will be more easily, more systematically, and more successfully answered.

But though the principles on which the constitution and general economy of the Army Medical Service are based may be alike for peace and war; and though unity of pattern may be attained in most of the instruments and articles of equipment in daily use by the officers of the department; such complete and perfect accord as may be attained in the organisation, exercises, equipment, and many of the administrative arrangements of the combatant parts of an army, cannot be accomplished in the medical branch. The circumstances of peace and war differ too greatly to allow the same details of hospital administration and duties to be employed in the two conditions of service. In time of peace, the wants of the sick and hurt of an army can be more economically, and more satisfactorily, ministered to in permanent hospitals furnished with standing equipment. In time of war, when once troops have taken the field, such fixed establishments are only available under very exceptional circumstances. It is uncertain where battles, entailing the necessity for surgical attendance on an enormous scale, may be fought, and, independently of these occasional demands, there is a constant need of medical and surgical help on the line of march, in the bivouac, and, indeed, in all situations where soldiers may be placed

during a campaign. These numerous wants must be considered and provided for before the troops start on their expedition. They must be met when they occur by means of establishments which move along with the army, and by an action on the part of the surgical staff which must be specially adapted to the particular circumstances under which the demands arise. As it is in the expectation of having to fight battles that armies are usually set in motion; as it is on the occurrence of general actions that the numbers of wounded assume the most considerable proportions; and as these are the occasions on which the resources and energies of the surgeons are most severely tried—it naturally follows that the needs of battle are especially kept in view when the organisation and equipment of the surgical portion of an army are being considered. All other surgical arrangements for a campaign must be subordinate to those for supplying the great and trying needs which will arise on the day of battle.

Needs of the wounded when a battle is fought.—It will be useful to consider briefly what the surgical necessities of men wounded in a great battle are. A review of these necessities will render a study of the best means of meeting them all the easier.

Some of the wounded will be able to make their way unassisted to a place of shelter and help; others, from the nature of their wounds, will be deprived of this power. Many of these latter, if they are to be moved away at all, must be carried. The wounds of all will require some surgical attention. In certain instances the performance of early operations will be essential for saving life; in others, the application of supports to protect the wounded parts from increased injury, during the removal of the men to the rear of the scene of action, will be of vital importance. After receiving such preliminary attention, the wounded will require to be removed to some of the field hospitals for definite treatment. The condition to which many of the wounded will be reduced renders it desirable that these hospitals should be as little remote from the scene of conflict as practicable. The time during which the patients can remain in the field hospitals where they are first received must vary with many circumstances. The nature and gravity of their wounds, the amount of accommodation available, the opportunities of transport, the situation of the hospitals, the course of the military operations and movements, the system adopted in regard to removal and dissemination of patients, and many other such matters, will influence the duration of their stay in them. It may happen that the patients will be retained in the field hospitals only a few hours, and then be sent on to other hospitals more in the rear, or they may remain in them for a few days, or even several weeks, before removal. If the field hospitals are established in villages or towns, the period of their stay may be prolonged until they have become convalescent. From these

hospitals they will either be discharged to return to their duties in the ranks, or they will be sent to a general hospital at the base of the military operations, from which those among them who have become disabled by their wounds will be sent away as *invalids* to their native country. There they will be disposed of according to the nature and final results of their injuries.

Subdivisions of the subject of army hospital organisation.—In studying the plans which appear best suited to meet the necessities which have just been described, it will be convenient to subdivide the subject under the two following heads:—(A) The Personal Staff necessary and its Organisation; and (B) The Ambulance and Hospital Establishments necessary and their Organisation. These will be treated upon in the present chapter.

A. The Personal Staff necessary and its Organisation.

The personal staff required for the care of the wounded in time of war, with due regard to their necessities already enumerated, consists of several distinct sections. When classified according to the nature of the duties which have to be performed by them, they are: (1) *the bearer personnel;* (2) *the surgical personnel;* (3) *the personnel of the movable field hospitals;* (4) *the personnel for preserving order;* (5) *the train personnel;* (6) *servants to officers;* (7) *the personnel of the hospitals between the field hospitals and the base of the military operations; and* (8) *the personnel of the general hospital at the base.*

In remarking upon these divisions of the personnel, the arrangements ordered by the existing regulations of the British service will be almost exclusively kept in view.

1. **The bearer personnel.**—The staff told off for picking up and removing wounded soldiers from fields of battle stand first in the list, as their duties are the earliest to be performed in helping the wounded. The need for a special personnel of this denomination will be apparent on slight reflection.

It is obvious that those officers and soldiers who are so severely wounded as to be unable to make their own way out of the conflict, must either be left where they have happened to fall until the fighting ceases, and be exposed to the risks of additional wounds from the fire of the troops opposed to them, as well as to injuries from the horses, guns, and troops moving rapidly in their vicinity; or they must be removed to the rear by some of their comrades, or by men specially provided for the purpose.

All must desire that men badly wounded in action, and consequently deprived of the power of defence as well as of offence, should not be subjected to the mental torture, increased bodily

suffering, and serious risks, inseparable from the first-named alternative. The evils of the second alternative are well known. The number of fighting men abstracted from the ranks when wounded men are carried off by their comrades, the difficulties of getting many of them to return, the resulting disorder and confusion, have been often described, and need not be dwelt upon here.

Defective arrangements formerly in the British army.—The natural feeling against wounded men being left on the ground uncared for, and the powerful objections against their removal from the field by comrades, caused, during many years past, special arrangements to be made in all the principal Continental armies for meeting this particular want. There used to be a grave deficiency in this respect in the arrangements of the British military service. Until a recent period the only men available for the duties of bearers of wounded in the British army were the bandsmen of regiments. But the dependence on bandsmen for this service was always very unsafe. No distinct regulations were ever promulgated on the subject; nor was any system adopted for educating bandsmen for the performance of the difficult and responsible duties which would devolve upon them if they were called upon to act as bearers of wounded. Their education and duties as musicians were of a special character, altogether foreign to those of sick-bearers. It is obvious to every one who is acquainted with the duties which bearers have to perform, that no system of collecting and carrying the wounded off a field of action can be complete which does not comprehend both theoretical and practical instruction. Constant difficulties and much preventible suffering must result in the absence of special education on such duties. Moreover, the instruction, once imparted, must be maintained by exercises at certain intervals of time, or the acquired dexterity will be lost. The art of removing wounded men and attending to their first necessities without aggravating their sufferings and adding to the gravity of their wounds, is a very difficult one. To practise it properly, special knowledge and manipulative expertness must be acquired, as well as habits of discipline and obedience; and to impart this knowledge and expertness to soldiers, a thoroughly organised establishment is as necessary as one to teach them the use of a rifle or any other technical operation. It is a duty, too, which is only fit to be intrusted to men who have the necessary physical qualifications,[1] and show that they possess tact and gentleness of character. To make a selection of men fit for becoming bearers of wounded requires skilled observation and experience, while considerable care and patience are necessary for their subsequent training.

Difficulties in organising a personnel for removal of

wounded.—When mentioning that the removal of wounded soldiers from fields of battle has always been one of the most defective parts of the army medical system of help during active operations in the field in the British service, it should also be stated that it is probably the most difficult part to arrange satisfactorily from an economical point of view. The difficulty is to organise a system for meeting a want, which is only a very occasional one, in such a way that the men concerned may be advantageously employed at other times when the particular need in question does not exist. It is true that the necessity which the combatants of an army are organised to meet—fighting—is also only an occasional one; but the general security is universally understood to depend largely on having men prepared to meet this want at all times, while the necessity for having men trained and ready for the removal of those who may fall wounded has been usually kept out of view. So also guns and other implements of warfare are only employed in the work they are specially contrived for at rare intervals, while it is certain that, whenever they are so employed, the need for the removal and care of wounded will simultaneously occur; but here again, although the importance of studious prevision with respect to every minute detail of the means of inflicting wounds has been universally acknowledged, the need for similarly careful preparation in the arrangements for meeting the surgical necessities which would result from their use has been recognised by few ruling authorities, and by them has hitherto been largely ignored in practice.

In countries where conscription is in force, corps organised, and specially drilled for the removal and transport of wounded men can be maintained without much difficulty. All who are liable to conscription feel a personal interest in the system of help in the field being kept ready and complete; while there is not the same paucity of men for the service, or costliness in maintaining them, as there must be in a country whose army is constituted on the principles of enlistment. It is easy in such countries to keep large reserves of men trained in the duties of bearers, to renew the training from time to time at suitable periods, and in case of the forces of the state being mobilised for war, then to call them into the ranks for service. This system has now become available, though in a more limited degree, for the British army; for, as a result of the short service system, trained men of the Medical Staff Corps, whose services could again be secured in case of need, have been for some years passing into the reserve forces of the country, while there is also a large body of men of the Militia Reserve who have been trained in the duties of the Medical Staff Corps, who would be similarly available for field service.

In the year 1876 the author was deputed by the Secretary of

State for War to act as president of a small committee to report on the appliances for aid to the sick and wounded in war which were then being exhibited at Brussels.[2] There were collected at this exhibition examples of the means which had been adopted by all the leading nationalities of Europe for the care and treatment of wounded soldiers in the field, from the moment when they were first hit in the fighting line to the time of their removal to hospitals away from the theatre of war. At that period there were no organised establishments in the British service analogous to the sanitary detachments, which, with differences of detail, existed in all Continental armies for bringing the wounded from the field, ministering to their most urgent needs in special dressing-stations, and for taking care of them until they were deposited in field hospitals. The advantages of these formations, and the drawbacks from their absence in our own service, were so manifest that, among other matters in our report, we specially invited the attention of the War Department to the necessity for providing trained stretcher-bearers and for organising dressing-stations. A special committee was subsequently assembled in London, by order of the Field-Marshal Commanding-in-Chief, to consider the subject. This committee met on several occasions, and the outcome of their deliberations was a recommendation that bearer companies should be instituted as a regular part of the British army organisation. A scheme of their establishment and constitution was submitted at the same time for the consideration of the War Department. In the year 1877 the establishment, as proposed, was authorised and was published in Army Orders.[3]

Some of the changes which have been made in the details of their constitution since that date are mentioned farther on.

Existing arrangements for the removal and care of wounded in the field.—The present system comprehends three distinct categories of personnel for ministering to the necessities of the wounded in time of war: (1) a regimental personnel; (2) the personnel of the bearer companies; and (3) the personnel of the field hospitals. The personnel of the field establishments just named is supplemented by additional personnel for the hospitals stationed along the line of communications between the active army and its base of operations, as well as for the general hospitals formed at or near the base itself. It is evidently contemplated by this division, not only that the persons appointed to these several establishments shall be charged with special duties and responsibilities, but that they shall form a connected chain of support, capable of adapting itself readily to meet any want of assistance that may occur along the whole line, whatever may be its extent or gravity. When an engagement is a slight one, and in the early period of a battle on a large scale, the regimental

personnel is expected to suffice for the first wants of the wounded, and for their removal to a place of shelter. When the engagement is of a critical character, and the number of wounded is greater than the regimental personnel is adequate to deal with, there is the brigade bearer company for meeting the increased demands for transport and professional assistance. On a field hospital being opened, the system of help, so far as concerns the personnel on the field of action, is rendered complete. The personnel of the intermediate and base hospitals is subsidiary to that with the army in the field.

Regimental bearers.—The regimental personnel consists of a medical officer attached to the regiment on taking the field, a regimental corporal and orderly, together with certain bearers, who are also to be obtained from the ranks of the regiment. It is laid down in the Queen's Regulations for the Army, and in the Official Medical Regulations, that when an action is expected the trained stretcher-bearers of a corps, in the proportion of two per company, will be placed at the disposal of the medical officer attached to the corps, for giving early aid to the wounded. Supposing, then, that two men of each regimental company are available for the purpose, they will be able to meet some of the first wants, and to remove a few of the wounded men, at the commencement of an engagement, or when part of a regiment is detached on outpost or other duties. Eight stretchers are supplied for the purpose, and are carried on the company carts. But for these regimental soldiers to be employed as bearers, they must first receive authorising orders from the officer commanding, to enable them to discharge the duty; and only after such orders can they receive directions in respect to the wounded from the medical officer with the troops.

The employment of two regimental bearers from each company would only diminish the fighting strength by sixteen rifles; and, on the other hand, ought to obviate the evil of other soldiers leaving the ranks to assist the wounded. The late General Sir William Codrington once observed, 'The only way of preventing the tendency to help wounded comrades off the field is to have men whose special function it is to help them. When this is done, it becomes a breach of duty for any other person to leave the ranks.'[4] The training of regimental bearers need not go beyond the proper modes of removing wounded men on stretchers, giving the simplest kinds of first assistance to them, and should not take more than three, or four weeks at the farthest, for its acquirement. It is recommended that four men should be trained in each company, so that two may always be ready for the duty. At the same time, the regimental bearers ought to be exercised at some regular periods with the 'Bearer Companies,' upon whom the service of removing the wounded must mainly depend, in the same manner as military manœuvres are practised by the combatant troops.

While wearing the uniform of their regiments, such auxiliary bearers are in some armies distinguished from the rest of the men of the regiment by a distinguishing arm-badge.[5] Some officers have felt uncertain as to the practical working of the arrangement just described. They have entertained doubts whether, under all circumstances, an officer commanding a corps in the field which is about to be engaged with an enemy will consent to his force being weakened even by two men per company. A British battalion is usually so weak in number relatively to a Continental battalion that a commanding officer may well hesitate, for the sake of the safety of the whole body under his command, to lessen his effective strength even by sixteen rifles on going into action. And it is in this early period of an engagement that the regimental bearers would be of most service, before the bearers of the bearer company can be on the spot. But the orders in the Queen's Regulations that two trained bearers per company are to be placed under the direction of the medical officer attached to each regiment in the field on such occasions are very distinct.

The bearers of the bearer company.—The personnel of a bearer company as it was first organised principally consisted of a corps of stretcher-carriers 95 in number, and was formed for the express duty of gathering the wounded, giving them first attention, and carrying them to ambulance waggons for removal to the dressing-stations and to the field hospitals. The company also comprised a staff of medical officers, with non-commissioned officers and men of the Army Hospital Corps for the subordinate duties of the dressing-stations. A personnel for conducting the transport of the wounded by the wheeled vehicles completed the establishment.

According to this original constitution the bearers were only added on the company being completed for active service in the field. In time of peace they were to be retained in the 1st Class Army Reserve. It was intended that a proportion of the Army Hospital Corps should be only enlisted for such a time as would enable the men to be properly instructed in the duties of bearers, and that, when this instruction had been completed, they should be passed for the remainder of their engagement into the Reserve just named. After a time the Army Hospital Corps would then have consisted of two separate classes: one would be a class of skilled hospital attendants, and would be retained for duty in the hospitals; the other would consist of stretcher-carriers, and would be retained in the Reserve, ready to supplement the corps for field service on occasion of war.

The training of stretcher-carriers of this description, judging from what has been done elsewhere, should not occupy more than a month. In this period, men of ordinary intelligence will become fully competent to act as bearers; to apply, in the absence of a

surgeon, such primary apparatus as may be of advantage to the wounded; to learn to distinguish between living and dead lying on the field; and also to discharge the military duties of guarding stores and conveyances, and performing fatigues and other such services as are usually required from privates in the field. The duties of all bearers require them to expose themselves freely to fire while the action lasts; the weight to be carried by them and the ground to be passed over are considerable; the position of the load irksome; and therefore, in addition to the necessary training and manual skill, it is evident that coolness, courage, activity, and strength are essential qualities for all such men to possess.

Since the year 1883 the personnel of a bearer company has been reduced in number. Its personnel still comprises officers of the Medical Staff, with non-commissioned officers and men of the Medical Staff Corps, and an establishment of the Army Service Corps attached for the transport duties. But the bearers consist of privates who have been fully trained, and have completed their time of active service in the ranks of the Medical Staff Corps or Militia, and have subsequently passed into the Reserve.

The complete war establishment of a bearer company as at present settled ("Regs. for Medical Services," 1890, p. 387), including the personnel, equipment, and transport, is shown in the following table:—

Constitution of a Bearer Company.

MEDICAL STAFF.	
Surgeon-major	1
Surgeon captains or lieutenants	2
MEDICAL STAFF CORPS.	
Warrant officer	1
SERGEANTS.	
Quartermaster-sergeant	1
Compounder	1
Sergeants	4
Bugler	1
RANK AND FILE.	
Corporals	6
Privates	8
,, cooks	3
,, bearers [1]	32
,, servants	3
,, supernumerary	1
TRANSPORT ARMY SERVICE CORPS.	
Subaltern officer	1
Sergeant	1
Artificers	2
Trumpeter	1
Corporal	1
2nd corporal	1
Privates as drivers	29
Batman	1
Cook	1
Supernumeraries	3
TRANSPORT VEHICLES.	
Ambulance waggons	10
G. S. waggons for medical stores and equipments	2
G. S. waggon for A. S. C. details	1
Carts for forage and tents	2
Water-cart	1
HORSES.	
Riding and draught	63

2. Surgical personnel in general.—The duties and responsibilities assigned to the different sections and grades into which

[1] Supplied from the Medical Staff Reserve or from the Militia Reserve.

military surgical personnel is ordinarily divided, vary considerably in different countries. The medical establishments connected with the military forces of Great Britain have been much extended of late years, and with this extension the responsibility of the Army Medical Department has been increased; for, in addition to the officers of the Medical Staff, the non-commissioned officers, and men of the Medical Staff Corps, the Female Nursing Corps, and other establishments of the regular army, the administration of the Militia Reserve of the Medical Staff Corps, and of the Volunteer Medical Staff Corps, has been placed under its direction. The duties of the supply branch, which were formerly executed by hospital purveyors, and subsequently transferred to the Commissariat Department, are now vested in the Army Service Corps.

The general duties of the officers of the Medical Staff are thus described in the most recent code of army medical regulations. They are 'charged not only with the medical care of the sick, the administration of military hospitals both in peace and war, and the command of the Medical Staff Corps, but with the duty of recommending to general and other officers commanding, verbally or in writing, any precautionary or remedial measures relating to barracks, encampments, garrisons, stations, hospitals, transports, diets, dress, drills, and duties which may, in their opinion, conduce to the preservation of the health of the troops, and to the mitigation or prevention of disease in the army. They will be employed in military hospitals at home and abroad, and with troops in barracks or in the field; and also on all such special duties in camp and quarters as the Director-General may decide.'

All particulars regarding the execution of the duties with which the various sections and grades of the Medical Staff are charged will be found in the 'Regulations for Army Medical Services,' published by the War Office in 1893, from which the foregoing paragraph has been extracted.

Medical officers.—Army Medical Officers, both executive and administrative medical officers, require many qualifications and various descriptions of knowledge to enable them to discharge their multifarious functions in a satisfactory way. The executive medical officers must be prepared to practise all branches of the healing art, whether as surgeons, physicians, or accoucheurs. The special divisions of surgical and medical science, and the particular applications to certain subjects, to which practitioners in civil life devote themselves, are altogether inadmissible in military practice. The army surgeon must comprehend in his range the whole sphere of professional science and practice. He must, in addition, possess a variety of other knowledge peculiar to army practice, in order to be a thoroughly efficient officer. He ought to be acquainted with the science and application of hygiene as regards bodies of men in all climates; the preparation of

various technical returns and reports; and the nature and uses of all the articles comprised under the general terms of field medical, surgical, and transport equipment. The army regulations bearing upon the management of patients in general hospitals and on field service, and those upon his own relations to other parts of the military service, should be all familiar to him. The duties and responsibilities which devolve on him as a commanding officer, in accordance with the rules laid down in the Regulations and Orders for the Army, must be well known to him; and he must be thoroughly conversant with the various drills and exercises peculiar to the Medical Staff Corps under his orders. Certain physical qualifications are also of essential importance to the army surgeon. He should have a healthy and robust constitution, in order to resist successfully the exposure and various trying circumstances incidental to military life in general, and especially to campaigning. High moral qualities, to ensure him due respect from those with whom he is associated, and to procure the esteem and confidence of the men placed in his medical charge, should also not be wanting.

The administrative medical officers should have passed through the grades of executive officers, and should have proved their fitness for the higher posts by superior scientific and moral qualifications while in those grades. In addition, the officers selected for administrative appointments should have shown themselves prudent, sagacious, capable of dealing with sudden emergencies promptly, and thoroughly imbued with habits of military discipline. It is equally true of medical as of combatant officers—those who have conducted themselves best in subordinate positions will almost always conduct themselves best also when placed in superior positions. Circumspection and judgment in command; the ability and decision of character which will impress the military authorities with respect for opinions and advice; scientific ability; the administrative tact, in addition, which will procure willing obedience and excite professional zeal among the executive officers and departmental functionaries under their administration; these are the qualities which will mark the most successful administrative officers of the Army Medical Service.

Consulting surgeons and special operating surgeons.—Certain specially functioned medical officers have been comprehended in the surgical arrangements for time of war in some armies, who have never been included in the personnel of the British army. Such are consulting surgeons and operating surgeons.

Of late years in the North German army, on the occurrence of war, the most eminent hospital surgeons in civil practice have been attached to the army as consulting surgeons. One such consulting surgeon, with the rank of surgeon-general, was attached

to each German corps-d'armée during the Franco-German war. There are undoubted advantages in having for an army the help of surgeons who, in consequence of their distinguished scientific attainments, vast experience, and known skill in operative practice, are acknowledged to be experts of the highest authority in the surgical profession; but the arrangement has been occasionally attended with difficulty, and is one which must be conducted with special tact and discretion for it to work smoothly in practice.

A peculiar feature of the field hospital organisation during the war of the rebellion in the United States was the appointment of certain medical officers and assistants, without regard to rank, for the special duty of performing the surgical operations required during and after an action. It was the province of the surgeon-in-chief of each division, acting under the orders of the medical director of the army corps to which the division belonged, to select surgeons for the particular duty mentioned, choosing them for their known skill and judgment as operators. This, no doubt, arose from the hurried circumstances under which the American armies were at first organised; so that it was impossible to avoid the admission of some surgeons without the necessary experience and dexterity in operating qualities, the possession of which is of such extreme importance as regards not only the limbs, but frequently the lives, of those who have to undergo surgical treatment on a field of battle. There can be no doubt that known adepts as operating surgeons ought always to be placed in positions where their superior skill can be best turned to account. But the competitive ordeal in London, in the first instance, and the subsequent special training which the surgeons of the British army pass through before they are admitted into its ranks, together with the tests prior to promotion, ought to render any restriction in respect to the performance of surgical operations by those upon whom such duties are likely to fall, unnecessary under ordinary circumstances. It is expected that the knowledge which they have gained of operative surgery before joining the ranks of the Medical Staff, and therefore a right sense of the importance of its possession, will cause all military surgeons to maintain and increase it by study, and by taking advantage of every opportunity that occurs for manual practice afterwards. If any fail to add to their experience in this way, they must inevitably fall back in surgical knowledge, and lose the dexterity they may have previously acquired; for of all technical skill, that of the surgeon slips away most readily without practice; and in any such case, on the occurrence of an action, it would be the duty of the administrative officers in charge, in the interest of patients, to restrict the officer found to be devoid of adequate skill from acting as an operating surgeon, and to direct another surgeon to take his

place. Professional mistakes in the use of the knife rarely admit of remedy.

The Medical Staff Corps.—In September 1884 a royal warrant was issued in which it was ordered that from that date the warrant officers, non-commissioned officers, and men of the Army Hospital Corps, should be designated the Medical Staff Corps. This corps, which numbers about 2500 non-commissioned officers and men, furnishes all the subordinate staff for the fixed and field hospitals of the British army. They are under the immediate command of the officers of the Medical Staff. The non-commissioned officers are responsible for the care of all the medicines, surgical instruments and appliances, in the army medical stores and elsewhere; and they perform the important duties of dispensers and compounders of the prescriptions of the medical officers. Its personnel are directly intrusted with the nursing and attendance upon the sick and wounded by day and night; with maintenance of order and cleanliness in and about the wards; with charge of the kits and all other property of the sick admitted into hospital; with the cooking and distribution of diets, and all other details of interior hospital economy. They have the care of all buildings, grounds, and enclosures while in hospital use, acting under the general orders and directions of the principal medical officer. They are required to pitch, strike, and pack with celerity the hospital marquees and tents; to be familiar with the manipulation and preservation in good order of all articles of field hospital equipment, and with all other duties appertaining to hospitals in the field. They have the necessary training to fit them for acting as bearers of wounded in case of need, and as guards over them during transport in wheeled and other conveyances.[6] Each man of the Medical Staff Corps, while a recruit, goes through a systematic course of instruction in the above-named subjects at the Aldershot Training School; and when that is satisfactorily passed, he is sent to a general hospital, to be inducted into the practical duties of an attendant upon the sick. As before mentioned, the men of the corps are enlisted on the short-service system, and when their term of service in the ranks has expired, they pass into the Medical Staff Corps Reserve.

3. Field hospital personnel. — Former regulations admitted only two classes of the medical personnel of army hospitals—regimental medical officers, and staff medical officers; the former for duty in regimental hospitals, the latter for duty in general hospitals, of whatever size or wherever established.

In the year 1873 regimental hospitals and regimental surgeons, with a few special exceptions, ceased to exist, and military hospitals were ordered to be organised and administered either as general, station, or field hospitals.

Field hospitals after the Crimean war underwent various

changes as regarded equipment; but no fixed grades or amount of personnel were allotted to them—the personnel was left to be supplied by the Director-General according to local circumstances, and to be distributed under direction of the principal medical officer on the spot. Subsequently a special establishment of personnel was ordered for each field hospital, and since the introduction of that arrangement all field hospitals in the British service have been constituted with a definite personnel on a fixed footing. The special purposes of the system will be explained hereafter. Various modifications have been made from time to time in the details of the establishments of field hospitals, which need not be described here. It will be sufficient in this place to mention the numbers and functions of the personnel belonging to a field hospital according to existing regulations.

Each field hospital is now formed to accommodate 100 patients, and is divisible into two half field hospitals. The following table shows the composition of the personnel, with the amount of transport assigned to a field hospital for its war establishment when wheeled vehicles are employed:—

PERSONNEL.		
Surgeon-lieut.-colonel in charge	1	
Surgeon-major	1	
Surgeons, captains or lieutenants	2	
Quartermaster	1	
Officers, Medical Staff		5
Warrant-officer, M. S. C.	1	
Staff-sergts. and sergts., M. S. C.—		
Ward-master	1	
Steward	1	
Compounders	2	
Cook	1	
Pack storekeeper	1	
Supernumerary	1	
Rank and file, M. S. C.—		
Corporal as steward	1	
,, cook	1	
,, clerk	1	
,, supernumerary	1	
Privates as ward orderlies	14	
,, cook	1	
,, pack storekeeper	1	
,, messenger	1	
,, washermen	2	
,, servants	5	
,, supernumeraries	4	
Medical Staff Corps		40
Warrant-officer, Army Service Corps	1	
Sergeant ,, ,,	1	
Corporals ,, ,,	2	
Artificer ,, ,,	1	
Drivers, &c. ,, ,,	21	
Army Service Corps		26
Total personnel		71

TRANSPORT.	
General service waggons for baggage, equipment, and reserve rations	2
Ditto for medical and surgical equipment	4
Ditto for A. S. C. details	1
Cart for supplies	1
,, tents	1
Water-carts	2
Vehicles	11

HORSES.	
Riding	6
Draught	36
Total horses	42

TENTS.	
For officers (circular)	3
For warrant, non.-com. officers, and men (circular)	4
For guard	1
Operating tent	1
For patients	25
Total tents	34

4. Personnel for preserving order.—Many irregularities are liable to occur in the rear of troops engaged in action against an enemy. They do not result so much from acts of the troops themselves, as of camp followers, hired or requisitioned transport drivers, and other inhabitants of the country in which the war is being carried on. The wounded and the hospital establishments have been especially liable to depredations on such occasions. Those who are charged with the ordinary military discipline of the personnel of the bearer and field-hospital establishments have urgent duties which engage all their attention at such times. A body of Military Police, amounting in number in an army corps to 46 non-commissioned officers and men, mounted, and 71 dismounted, are now distributed under the command of an officer among the several parts of the force, so that all irregular interference with the property of the wounded, and disorder in the vicinity of the ambulance or hospital establishments, ought in future to be under control.

5. Ambulance train personnel.—The subject of the 'Train Personnel' is intimately connected with the 'Bearer Personnel,' that has been already described. The distinguished officers who were appointed in 1866 to inquire into the administration of the transport and supply departments of the army, recommended in their report that an 'ambulance train,' formed of picked and specially trained drivers and officers, should be organised; that there should be kept up a peace establishment of ambulance vehicles, mules for litters, &c.; that the conductors of these vehicles and animals should at certain periods be attached to and do duty with the Army Hospital Corps; and that the men of the ambulance train should have the arm brassard of the Geneva Convention on their uniform. The committee reported that 'the arrangements for removing wounded soldiers out of action, and for the transport duties connected with the hospitals, are, in the opinion of the committee, in a very undefined and unsatisfactory state as regards both the responsibility for, and the means and appliances of, the service. The evidence shows how ill understood and how imperfectly provided for by regulation are the relative responsibilities of officers regarding transport of sick and wounded.' Much of this uncertainty has been removed by changes in organisation since that date. The formation of an ambulance train, such as was recommended by this committee, has not been carried out; but the duty of removing the sick and wounded of the army in war, as before mentioned, and also of conveying them to and fro as may be required in time of peace, has been given over to the Army Service Corps. It is an important matter for the sick and wounded —considering the peculiar nature of the service—that a special training should be given to certain selected transport officers and drivers of the Army Service Corps in ambulance transport, and

that they should be familiarised in co-operating with the bearers and hospital attendants, as the committee recommended. No special instructions regarding ambulance transport, beyond those for fitting ambulance litters and cacolets on mules, are given in the regulations for the Army Service Corps. But even the driving of ambulance waggons when they contain badly wounded or very feeble men requires more method and consideration than are likely to be given to the subject by drivers whose usual charge consists of inert stores. Trained attendants of the Medical Staff Corps may not be always available for accompanying wounded in the conveyances used for their transport in the field.

The propriety of employing in field hospital service men belonging to a combatant corps, as the Army Service Corps is, from the point of view of international obligations, has been warmly questioned. But the terms of the second article of the Convention of Geneva of 1864 provide that such men, when, under the regulations and order of the Government of the country to which they belong, they are told off for hospital duty during a campaign, may legitimately wear the red-cross brassard, and claim the immunity which the treaty confers, so long as they are actually engaged in the service of the sick and wounded. The whole spirit and wording of the Convention are intended for the succour of wounded soldiers in the field; and it is in the interest of the wounded that this transport should be executed by the most able men at the disposal of the Government and in the most suitable way, without interruption, that circumstances allow.

There are certainly more difficulties to cope with when the transport duties are provided from an outside corps than there would be if they were performed by men of a special hospital transport corps. The combatant uniform may cause mistakes to which men wearing the ordinary uniform of the Medical Staff Corps would not be liable, and the small brassard is not conspicuous at a distance. Special supervision and orders will be necessary to prevent abuse of the license to wear the brassard, among men who are at one time acting as combatants, at another as men of a sanitary corps. The temptation to use the brassard surreptitiously when not employed in hospital duties, for the purpose of avoiding capture or violence, if the brassard is permitted to be retained by the men, may occasionally be almost irresistible. Such risks of misuse and fraud will have to be provided against. But that combatants can be legitimately employed in hospital duties while a campaign lasts, and have a strict title to the advantages of neutrality while so occupied which the Governments who are signatories to the Geneva Convention have agreed to, does not admit of doubt.

6. Servants to officers.—A necessary part of the personnel of all hospital establishments in the field are servants for the medical officers. When they are not provided by the public, the officers have to devote part of the time to their own concerns which should be devoted to their patients. It has been the custom in the British service, as regards army surgeons on general duty, to trust to the hire of private servants. This system answers sufficiently well in time of peace; but, not to speak of the military objections to civilians moving to and fro in the ranks of an army, it has always been very difficult to obtain them under any circumstances in time of war, and often, when obtained, it has not been possible to get them to stay. They will not submit to the exposure and privations inseparable from campaigning; and these are all the more felt by them, because they cannot have the privileges and advantages which soldiers and all military subordinates possess in the field. During the Crimean war it not unfrequently happened that staff surgeons had to clean their own boots and appointments, and to procure and prepare their own meals. This could not be done without the interests of the sick and wounded suffering. In the constitution of some Continental field hospitals the personnel includes military servants, distinct from the attendants on the sick. To employ hospital attendants as servants to medical officers seems to be an objectionable proceeding. Army hospital attendants are trained and paid for other and more important duties, and their time and services ought not to be diverted from their legitimate functions, if it be possible to avoid it. It will rarely occur that they are not wholly required by the sick.[7] The servants, however, who form part of the personnel in the official establishments of the bearer companies and field hospitals are taken from the ranks of the Medical Staff Corps.

Surgical personnel with an army corps on active service.—The surgical personnel with a force acting against an enemy is divided into two distinct categories, viz., (1) the personnel forming part of the force actively engaged in the field movements and operations under the direct command of the general commanding-in-chief; and (2) the personnel of the establishments in rear of the active army in the field, who perform their duties under the orders of the general officer commanding the lines of communication and base. Presuming the force in the field to have the strength of one army corps, which by recent regulations would consist of 35,087 officers, non-commissioned officers, and men, together with a cavalry division of 6700 troops, the surgical personnel would comprise the medical officers attached to the headquarter staff of the army corps, to the staffs of 3 infantry divisions, 1 cavalry division, to the various regimental units in the field, to 8 bearer companies, and 13 field hospitals. The

number of surgeons assigned to these various services is as follows:—

With army corps staff	Surgeons	4
,, four infantry division staffs	,,	12
,, regimental units	,,	41
,, eight bearer companies	,,	24
,, thirteen field hospitals	,,	65
	Total	146

7. Surgical personnel with the establishments between the active army and its base.—By former regulations it was ordered that thirteen field hospitals should be stationed along the lines of communication in rear of the army or at the base of operations; it is now ordered that there shall be two stationary hospitals, each capable of containing 200 beds, and two general hospitals of 400 beds each, on the line of communication and at the base. In addition to the personnel of these establishments, there is also a small surgical personnel with the advanced depôt of medical stores, and with the military depôt at the base of operations.

The personnel of a stationary hospital of 200 beds is laid down as follows:—1 brigade surgeon-lieutenant-colonel; 2 surgeon-lieutenant-colonels; 2 surgeon-majors; 4 surgeon captains or lieutenants; 1 quartermaster; 1 sergeant-major, 64 sergeants, corporals, and privates, of the Medical Staff Corps, with 10 servants and batmen. Arrangements are made for this establishment being divisible into four sections in case of need.

The following is the authorised personnel of a general hospital of 400 beds:—

MEDICAL STAFF.	
Surgeon-colonel in charge	1
Surgeon-major, secretary and registrar	1
Brigade surgeons-lieut.-colonels	2
Surgeon-lieut.-colonels	2
Surgeon-majors	4
Surgeon captains or lieutenants	8
Quartermaster	1
MEDICAL STAFF CORPS.	
Sergeant-majors	3
Staff-sergeants and sergeants	11
Corporals	10
Privates	76
Batmen	19
Bugler	1
Interpreter	1
	140

NURSING SISTERS.	
Lady superintendent	1
Nurses	7
Female servants	2
	10

Note.—If a general hospital is organised for 500 beds, the following personnel is to be added:—

Surgeon-captains	2
Sergeants	2
Corporals	2
Privates	18
Batmen	2
Nurse	1
	27

At the advanced depôt of medical and surgical stores at the head of the line of communications, the medical personnel is

limited to 1 surgeon-major, with 1 sergeant compounder of medicines, 1 corporal as clerk, and 2 rank and file of the Medical Staff Corps.

At the base, which is under the command of a brigadier-general or colonel-on-staff, the medical personnel consists of 1 principal medical officer, 1 embarking medical officer, 1 surgeon-major, 2 quartermasters of the Medical Staff; with 4 staff-sergeants and sergeants, and 8 rank and file of the Medical Staff Corps. The personnel just enumerated includes the staff of the depôt of medical and surgical stores which is established at the base for the supply of medical stores and appliances to all the hospitals of the army, as well as to those on board ship. This depôt is in direct communication with the magazines of such stores in England.

The medical personnel with the headquarters staff of the line of communications consists of a principal medical officer, who is P.M.O. of the whole army in the field; a medical officer to act as secretary; and a third to act as orderly medical officer, with 4 clerks in the P.M.O.'s office. Provision is made for a deputy P.M.O. to be added if the length of the line of communications requires it.

The total war establishment of the Army Medical Department on the line of communication with an army in the field, in a temperate climate, and on the presumption that the line is about 100 miles long, is estimated to be as follows:—

	Officers.	Warrant, Non-Com. Officers, and Men.	Civilians.
With headquarters staff . .	3	7	...
Staff at base	5	17	...
At advanced depôt	1	5	...
With two general hospitals of 400 beds each . .	38	240	20
With two stationary hospitals of 200 beds each . .	20	150	...
With units	5	...	...
	72	419	20

Selection and distribution of the surgical personnel.—Having now mentioned the principal classes of personnel which are allotted for carrying on the duties connected with the medical care and treatment of wounded men in the field, it may be useful to indicate the manner in which this personnel is generally distributed. The following have been the usual arrangements. The Director-General, under authority of the Minister for War, nominates the principal medical officer of the army taking the field,

and provides and despatches the number of surgeons of all ranks destined for the campaign. In the field, the principal medical officer of the army has hitherto received his orders from the general officer commanding-in-chief, or from the chief of his staff; but by recent regulations it is directed that the principal medical officer will be under the orders of the general officer commanding the lines of communication, and will have his headquarters with him, but is to be available, when required, for consultation with the general commanding-in-chief on subjects bearing on the health and physical efficiency of the troops. It is also directed that the responsibility of the principal medical officer for all medical arrangements and establishments connected with the force in the field is to be subject to the orders of the general officer commanding the lines of communication.[8]

It might well have been anticipated that, as a lieutenant-general is appointed specially to command the lines of communication with the army and base, so as to leave the general-in-chief free to give his whole attention to the concerns of the army actively engaged in the field, a medical officer would be similarly appointed on the staff of this lieutenant-general to attend to the numerous medical duties that require direction along the lines of communication and at the base, while the principal medical officer of the whole army would be in the field with the general commanding-in-chief, always at hand and ready to give any required information regarding the health of the troops, or to give instructions on the general concerns of his department. By former regulations it was so arranged. The principal medical officer of the whole army was in the field with the general officer in chief command, and a surgeon-general was nominated as principal medical officer under the orders of the lieutenant-general of the lines of communication, with a deputy surgeon-general as line inspector, and a second deputy surgeon-general as sanitary inspector, of the routes from the base to the advanced depôt. As the lieutenant-general of the line acts under the general authority of the general commanding-in-chief, so the principal medical officer of the line, in medical concerns, acted under the general directions of the senior principal medical officer in the field. It is presumed that the existing arrangement is chiefly due to motives of economy; but how it will work, in case of the day of trial coming, seems at least doubtful.

The distribution of the medical officers sent out by the Director-General has hitherto been settled locally by the principal medical officer of the army while the force has been assembling at the place of rendezvous. With the sanction of the general officer in command of the force, and acting in concert with the heads of other departments, he has allotted the medical officers to their several stations and duties: some for duty in the chief general

hospital, and any subsidiary field hospitals that might be formed at the base of operations; some retained for duty in the hospitals which might afterwards have to be established on the lines of communication, and to replace casualties in the field; some for charge of the field hospitals and duty in them; and others for charge and duty with the sick and wounded convoys. The surgeons attached to regiments have remained with the regiments to which they had been previously appointed.

Now that particular technical knowledge, practice, and special qualities will be essential for properly conducting the duties of certain establishments, such as that of a bearer company, or a movable field hospital, the personal arrangements will in future be made under the immediate authority of the Director-General before the force leaves England. He alone, on the first starting of an expedition, can have sufficient acquaintance with the capacities and qualities of the surgeons sent with it, to enable a right selection of them to be made for such charges. It is accordingly ordered, with regard to these establishments, that their personnel is to be assembled on their formation at the place of mobilisation, and to embark in the same vessel that carries them when they leave the home country.

The grades and strength of the surgeons appointed for some of the duties which have been described must vary to a certain extent according to accidental circumstances, so that the staffs laid down in the official field army establishments for the several medical services can only be regarded as estimates which are to be carried out whenever practicable.

By the Army Medical Regulations of 1878, the principal medical officer of an army in the field was to be assisted in the direction of all matters belonging to the hospital and medical arrangements by a field inspector, who was to perform such supervising and other duties over the whole field of operations as the principal medical officer might direct. A competent medical officer was attached to the quartermaster-general's department of the army as sanitary officer. The medical officer selected for this office, which was regarded as one of the highest importance, requiring very special qualifications, received his appointment, on the recommendation of the Director-General, directly from the Minister of War. His functions and responsibilities were defined in a special section of the official 'Sanitary Regulations for Field Service.'[9] The offices of medical field inspector and sanitary officer are not included in the present field army establishments, and the special duties which these officers were appointed to perform now devolve, by orders in the Regulations for Medical Services, on the principal medical officer himself.

In the distribution of army medical officers to the different duties which they have to perform in the field, other qualities,

in addition to the necessary professional acquirements, in the interests of the service, ought to be taken into account. The surgeon-major commanding a bearer company should be a thorough disciplinarian, active and strong, and a fearless rider. He should be gifted with tact, discretion, and knowledge of character, in order to direct judiciously and control the varied personnel concerned with his charge. He should have a quick perception of the leading features of ground, and some acquaintance with military exigencies, in order to dispose of his bearers, and to establish the dressing-stations, with the best advantage. The surgeon-major in charge of a field hospital need not have some of these qualities in the same degree; but they are all necessary, in addition to knowledge of hospital management, to enable him to discharge the duties of his position with credit. They are qualities which become less needed in the medical officers on duty as directors of stationary hospitals; and still less in those of general hospitals, where methodical habits, the power of close application, in addition to high professional ability, are of most importance as regards the duties which have to be directed and done in them. Unless consideration is given to these points in the selection of medical officers for particular charges, especially for such a command as that of a bearer company, failure must be expected. Under any circumstances, such charges present difficulties for medical officers who have not been habituated to them; but these difficulties will be greatly increased if the most suitable are not chosen for meeting them. Failure under such circumstances will be less the fault of the medical officer holding the charge, than of those who have placed him in it.

Supplementary medical officers.—No number has been calculated for the medical officers who have to accompany the convoys of sick and wounded from the field hospitals to the hospitals on the lines of communication and at the base, or for those with the men invalided to England. These numbers must vary with the varying necessities which the military operations give rise to, and many other circumstances; in the same way as the number of hospitals opened must depend upon the changing exigencies of the war, and the circumstances and condition of the troops engaged in it. There must always be a reserve of surgeons available, so that, when medical officers are detached for special purposes from any particular service to which they have been previously told off, they may be replaced from this supplementary staff; just as surgeons despatched from the base to England on duty, on account of ill-health, injury, or from any other cause, have to be replaced by others from England. Whatever may be the number of the surgical personnel originally assigned to troops proceeding on active service, it has generally been estimated that a reserve of one-fourth of that number ought to be maintained, in

order to have the means ready for meeting unexpected demands, and replacing casual losses from sickness or injury. There will probably be less difficulty in meeting such demands in future, as there is every reason to expect adequate reliefs will be available from the ranks of the Volunteer Medical Staff and from Voluntary Aid Societies. Help from these sources is contemplated in the Army Medical Regulations, and special rules are laid down regarding the appointment of volunteer surgeons and their disposal in the field. All medical officers of the auxiliary forces, and all civil surgeons who volunteer assistance, whose services are authorised by the general officer in command, on the recommendation of the principal medical officer of the army, are to be distributed for duty in such of the hospitals on the lines of communication and base as the principal medical officer may deem expedient. They are to act under the medical officers in charge of the hospitals to which they are attached. If the representative of a Volunteer Aid Society, not being a medical practitioner, brings under his direction a staff of surgeons and attendants whose services are authorised, the members of this staff are in like manner to be placed under the authority and at the disposal of the principal medical officer, who will allot such duties to them as he may think advisable. No civilian is to be allowed to visit a hospital unless he is provided with a pass signed by the medical officer in charge of it.

B. The Hospital and Ambulance Establishments necessary, and their Organisation.

General remarks.—It has been already mentioned that prior to the changes introduced in the Medical Department in 1873, there were only two kinds of hospitals in the British army—regimental and general hospitals.

But in time of war, when an army was in the field, it always happened that the regimental hospitals were so reduced in capacity that in fact they practically ceased to exist. Had they been maintained as in time of peace, they would have interfered with one of the most essential qualities of an army—a quality now become more important than ever—viz., its mobility. On the army going into cantonments or winter quarters, or becoming stationary for any lengthened period, the regimental hospitals might be expanded, but only to be again reduced when the army resumed active movement. On the other hand, general hospitals, which served the purpose of preventing regimental hospitals from being encumbered with patients, and were open to patients from every corps, were always increased in number and importance according to the nature and duration of the military operations.

Such general hospitals must always exist in time of war, and as they have to be established in situations possessing certain definite relations to the army moving in the field, they have been usually distinguished by names in accordance with these positions.

It will be convenient to study the hospital establishments in the order in which they are usually formed on a theatre of warfare, viz., from the base of the military operations to the field of action. Regarding them in this way they will consist of—(1) the principal general hospital, and its subsidiary establishments at the base of operations; (2) hospitals on the lines of communication; and (3) field hospitals, including (4) dressing-stations and (5) regimental stations. The necessary communications between these hospital establishments will have to be maintained by (6) field ambulance conveyances; (7) railway ambulance trains; or (8) convoys by road, or river hospital ships. Hospital ships and transport vessels will be used for communicating with (9) the permanent general hospitals in England.

The nature and formation of each of these several establishments, and the purposes they subserve, will now be described.

1. The principal general hospital at the base of operations.—When an army operating against an enemy belongs to a Continental power, the principal general hospital at the base is placed at the most convenient and safest situation near the frontier. When an expeditionary force starts from an insular country like Great Britain, the practice has hitherto been to establish it in a suitable building on the sea-coast, at some place where the army is collected, and from which it proceeds to its special destination. Into this hospital the soldiers who have become disabled from injury or illness in the transports since their departure from England have been at once admitted, and subsequently those who have fallen sick while the army has been in process of being formed at the place of rendezvous. Here also by degrees the great bulk of the sick and wounded from the troops in the field have been at last received. From it the patients who have not appeared likely to convalesce for a long time, or who have been permanently disabled by their wounds, after being arranged for in accordance with the invaliding regulations, have been discharged and sent by hospital ships or transports to England. The stores required for the surgical service, the apothecary's and all other hospital stores, were usually received here as they arrived from home; and from it the various supplies were drawn which the hospitals in front from time to time required.

Existing regulations have modified the functions of the general hospital at the base in several respects. It is still, as formerly, organised for receiving all patients sent from the hospitals in front and on the lines of communication, as well as every one who may fall sick at the base and is entitled to treatment in a military

hospital; but there is now attached to it a military depôt where many of the duties, not strictly medical, connected with the men passing through the hospital, are performed. A hospital ship moored at the seaboard or anchored a short distance off may be employed in place of a general hospital on shore, or may be used merely as supplementary to it. In any case, whether on shore or floating, the military depôt will be attached to it as part of the organisation of the general hospital. This depôt is directed to be under the command of a military officer of experience, and is provided with a considerable staff under his orders. It is designed for receiving all men discharged from further treatment in the hospital, whether men in restored health or invalids, and for arranging all matters connected with their subsequent movements, whatever may be their destination. The conduct of all correspondence not of a medical nature with the various corps to which the men passing through the hospital belong, the settlement of questions relating to their pay, the punishment of men committing offences while patients in hospital, and the disposal of many other matters not of a medical nature, are to be carried out at the military depôt. The necessary guards and fatigue parties for the hospital are also provided by the depôt on the requisition of the P.M.O. of the hospital. By these means it is intended that the medical officers doing duty in the general hospital shall be relieved from many matters which would otherwise have to be arranged by them, and thus have more time at their disposal for their professional work. If the general hospital at the base should from any cause have to change its position, the military depôt would have to move with it; indeed, from all points of view, it has to be regarded as an essential part of its organisation. The depôt for medical and surgical stores at the base has no longer any connection with the general hospital; it is separately constituted, with its own regulations, and its staff is included in that of the principal medical officer who is on the staff of the general commanding the base. The circumstances of war always cause the general hospital at the base to be the first hospital occupied, and the last used, in the course of a campaign whenever it takes place in a foreign country which is not occupied by the invading army after active hostilities have ceased.

2. **Hospitals on the lines of communication.**—These hospitals are placed at intervals along the lines of communication, and are intermediate between the movable field hospitals in front, and the base of the military operations at the port of embarkation. In the official publication on Field-Hospital Establishments they are designated either 'stationary' or 'general' hospitals. The former are, however, only temporarily stationary while required for their special service, and are equipped with a view to their being readily moved when necessary; while the general hospitals are larger

establishments, originally so called from receiving the sick and wounded of all corps alike without distinction. They are so placed along the lines of communication, whether they are railroads, ordinary vehicular roads, or water communication, as to receive without difficulty the wounded from the field hospitals. They are provided with sufficient medical and surgical stores for gravely disabled men to be treated and cared for in them until they are in a fit state to be sent on to the principal general hospital at or near the base, or who are waiting for opportunities of being sent there.

It is a recognised military principle that the sick and wounded of an army in face of an enemy are to be passed on as quickly as possible from the field to hospitals in rear. Disabled troops are not merely so many inefficient men, requiring food, care, and attention, but they would be serious hindrances to a commander if they were retained with the army. Neither could such patients be left in places devoid of due military protection; nor could the field surgeons be spared to be left behind with them if they were so placed, for they are constantly wanted with the army moving in the field, to meet the case of a fresh engagement occurring with the enemy. The field hospitals which are with the main body of the army have always to be kept in the lightest marching order possible, ready to afford temporary help and treatment to whatever number of wounded may result from the operations in which the troops are engaged. Hence it is that successive hospitals have to be established between the position of the army in the field as it advances, and the sphere of operations behind. They prevent an accumulation of disabled men in the movable field hospitals by taking the men from them; they benefit the patients by preventing any interruption in their treatment; and they assist in maintaining the strength of the active force in front by affording the means of speedily restoring to efficiency those who are only slightly injured, or are suffering from slight and temporary ailments. They also form the establishments where the results of most of the graver cases of wounds and sickness are determined prior to the transport of the patients to the base for removal to convalescent stations, or their transfer as invalids to the home country. Even in the earliest period of a campaign, before any conflict occurs with the enemy, the men who fall sick on the line of march require provision of this kind to be made for their reception. The number who leave the ranks from sickness, under the most favourable circumstances, when troops are on the move, is often remarkable. It has been calculated that from 4 to 5 in every 100 men will require hospital treatment in the course of a ten days' march. In an army corps of 36,000 men this means from 1440 to 1800 patients to be treated. If circumstances be unfavourable—whether as to climate, ground, diet, weather, or otherwise—the number of men requiring hospital treatment may be expected to be pro-

portionably increased. By present arrangements, each of the two general hospitals allotted to the lines of communication is divisible into four sections; and perhaps one of these sections may be utilised for the reception of the patients dropping from the force on its advance; and whether opened at or near a railway station, or in a village, in a detached building, or placed under canvas in a camp, it would become for the time an intermediate hospital.

The number of hospitals and depôt stations on the lines of communication with an army in the field, where medical relief, more or less complete, can be afforded to the sick on their way to or from the base of operations, which are established during a campaign, must depend upon the nature of the country in which the military operations are carried on; the distance to which an army penetrates; the changes in the direction of its movements; and the nature of the communications, whether vehicular roads, railroads, or water, which exist between it and its base. Their positions must necessarily be determined under the orders of the officer commanding the lines of communication; for he alone can be aware of the situations in which they will be safe, to which the necessary supplies can be carried, and to and from which the sick and wounded can be moved with least risk of interruption; while, in all professional concerns, they will depend on instructions from the principal medical officer at the headquarters of the lines of communication on which they are placed.

3. Field hospitals.—These are the hospital establishments which are actually with the troops and take part in their movements. They have a light equipment, in order that they may be able to move readily with them.

Requisite qualities of field hospitals.—The necessities of modern warfare point to the following as the requisite qualities of field hospitals. On the occurrence of an engagement with the enemy, they should be capable of at once receiving the wounded after their first necessities have been attended to at the appointed dressing-stations. They should have all the means for treating these patients, until they can be transferred to other hospitals in rear. They should be capable, as soon as the patients are removed, of being quickly packed up and brought within reach of the army again, should it be advancing, so as to be available for receiving a fresh number of wounded. They should have all the necessary means for temporarily treating patients who fall sick with ordinary camp diseases. The foregoing considerations lead to the necessity of each field hospital being complete in itself, as regards both its personnel and matériel; of its not being of undue size; of its stores being ample in quantity for several successive contingents of sick and wounded; and of its being so constituted that it can be speedily opened, speedily closed, and easily removed from place to place.

The organisation adopted for the new field hospitals of the British service is calculated to answer the purposes just described. The composition of the staff of one of these field hospitals has been shown in a tabular form at page 540. An army corps will have its complement of these hospitals attached to it, each being equipped and arranged, as before mentioned, for accommodating 100 patients, but divisible into two half hospitals, each for 50 patients. This division is only to be made under exceptional circumstances and special authority. One field hospital forms a component unit of every infantry brigade in the field; while with an army division consisting of two brigades, a third field hospital in reserve is added to the two belonging to the brigades. The field regulations order that the personnel and matériel, and if possible the transport, of each field hospital when proceeding abroad on active service, shall be embarked in the same vessel, and accompany the brigade to which it belongs. Great difficulty and confusion have resulted on former occasions from the complete establishment of field hospitals not having been at hand together when required. The transport and its special establishment, as before mentioned, are derived from the Army Service Corps.

Working of field hospitals.—Particular instructions on the manner of dealing with patients who have been received into a field hospital, on their dieting, the records to be kept regarding them, and on various other points of field hospital management, are given in the official medical regulations. The following outline will indicate the general working of the field hospitals. If a general action be expected, the two field hospitals will be brought as close to the division of the army to which they belong as circumstances permit. A village, a factory, a farm, or a mansion with outbuildings, if available, will be selected as the place for the hospitals; here the equipment will be unpacked and all surgical proceedings likely to occur prepared for. The field hospital when thus established will be made conspicuous by the hospital flags, and its site, and the routes to it, made known to the officer directing the operations of the bearer company. The wounded who are brought in will remain under treatment in it only as long as is absolutely necessary; it is merely intended that they should remain until they can properly be moved to the rear, especially if the troops are likely to make an advance. All patients that can bear removal will therefore be transferred to the nearest hospital in a direction toward the base as soon as practicable. If a fresh encounter is closely threatened, the hospital should be cleared, and the patients transported to the rear at once. If there are patients who are not in a fit condition to be so disposed of, one section of the field hospital establishment may remain to take care of them, and the other section move on with the army again. Or if circumstances render it desirable, the whole hospital may remain,

and be handed over as a stationary hospital on the lines of communication, and another field hospital brought forward in its place.

Position of the field hospital establishments on the line of march.—This is a most important arrangement to be settled, so that there may be no hesitation on the subject when the troops are in movement. On the one hand, the hospitals should not be permitted under any circumstances to interfere with the movements of the troops; on the other hand, they should be within reach and ready for use whenever they may be required. Both these points should be fully considered in laying down the positions of the field-hospital establishments on the line of march, which obviously should correspond, as nearly as practicable, with the positions they would have to occupy in case of the force becoming engaged. The official medical regulations only direct that on the line of march the field hospitals are to follow the bearer companies. The importance of fixing positions for them with precision becomes especially felt when it is a matter of doubt at what moment an enemy may be encountered, and a number of wounded require hospital treatment. It has too often happened that the hospital establishments have been so much in rear of the heavy baggage of the troops which they have been accompanying, that they have been out of reach at the time of need, with obstacles between them and the wounded which the utmost exertions could only overcome after a long period of delay had elapsed.

When the system of surgical help in the field is in working order, and a body of troops is on the line of march in an enemy's country, the equipment supplied for affording the first help on the field itself by the medical officers attached to corps is ordered to be carried in the regimental transport; while that of the dressing-stations, with the ambulance conveyances working with the bearer company, will probably move in rear of each divisional column, with the field hospitals behind.

It may be useful to notice the manner in which the three sanitary detachments and twelve field hospitals were distributed, when a German army corps, the 5th, to which they belonged, was on the march during the Franco-German war.[10]

ADVANCED GUARD.

1st Infantry Brigade of the 9th Division, with Cavalry, Artillery, and Engineers.
Half the Sanitary Detachment, No. 1.
The Light Baggage of the Advanced Guard.

MAIN BODY.

2nd Infantry Brigade of the 9th Division with Artillery.
Half the Sanitary Detachment, No. 1.
Field Hospitals, Nos. 1 and 2.
Light Baggage of 9th Division.
Two Brigades of the 10th Division, with Cavalry, Artillery, and Engineers.

MAIN BODY (*continued*).

Sanitary Detachment, No. 2.
Field Hospitals, Nos. 3 and 4.
Light Baggage of 10th Division.
Battery and Infantry Ammunition Waggons.
Sanitary Detachment, No. 3.
Field Hospital, No. 5.

TRAINS.

Provision Columns.
Heavy Baggage.
Remount Depôt.
Field Hospitals, Nos. 6 to 12.
Field Bakery Column.

It will be seen from this arrangement, that in case of the advanced guard becoming engaged, a section of a bearer company or sanitary detachment would be at hand to join with the battalion bearers in aiding the wounded, and to assist in carrying them from the place of fighting. If the engagement assumed larger proportions, so that a whole division was brought into action, the whole sanitary detachment would be made available for service, and two field hospitals could be opened if considered necessary. A similar amount of assistance was at hand with the second division, in case of need; and still further aid, should the fighting be prolonged and the number of wounded increased, was within reach, in rear of the whole main body. At a still greater distance off, with the train and columns of the army corps, seven field hospitals were in reserve, either to supplement those with the troops, in case of additional need, or to replace them, in case the hospitals occupied by wounded could not be evacuated, and had therefore to remain behind on the main body making an advance.

4. **Bearer companies and dressing-stations.**—The dressing-stations of the present day correspond in many respects with the light movable establishments for affording temporary surgical assistance, which were often called 'Flying Hospitals' in old days.[11] They are the first help-stations in the field at which the wounded can rely upon receiving skilled and deliberate treatment, they may get assistance, on the spur of the moment, as it were, at the fighting line, or at a place where the wounded are first collected, but it must unavoidably be of a very casual and improvised nature. The dressing-stations are establishments of a lighter and still more movable character than the field hospitals, being only organised for affording preliminary assistance to the wounded before they reach the field hospitals. They assume increased importance when the field hospitals are placed at a long distance off from the field of battle, as they must generally be in modern warfare. They were formerly constituted, when they existed at all in the British service, out of any regimental or staff medical officers and attendants that could be brought together, and of any articles suitable for the first dressing of wounds that might be at hand and available for the purpose. They now have a definite constitution, with an authorised establishment and fixed supplies of equipment.

A dressing-station, as now organised, is formed of a portion of the Surgical Staff, and Medical Staff Corps of a bearer company, supplemented by men and vehicles detached from the Army Service Corps. Dressing-stations do not depend upon the field-hospital establishments, as of old, either for surgeons, attendants, or dressing materials. There is no reason why some of the medical officers attached to regiments and corps should not be lent to

assist in the duties of the dressing-stations during an action, when there is extra pressure at them. It is especially ordered in the regulations for hospitals in the field, that medical officers attached to battalions and corps units for duty in the field, while under the orders of the officer commanding the unit, will be at the disposal of the principal medical officer of the division in which he is serving, so that the principal medical officer has the power of ordering some of the corps surgeons to assist in the duties of the dressing-station if he thinks their services likely to be of more benefit to the wounded in the latter than in the former position.

All the equipment carried for use at dressing-stations is of a very movable description; not only that it may be readily kept up with the troops while they are on the march, but also because, from the nature of dressing-stations, they may suddenly have to change their position at any time during the progress of an action.

The position of a dressing-station established on any particular occasion must vary with the extent of field over which the fighting is going on, the military features of the ground where the action is proceeding, and the facilities of bringing the wounded to it. It should not be so near to the fighting line as to be exposed to shot from the enemy's fire, and yet not more distant than safety actually requires.

A list of the personnel and the constitution of a bearer company have been shown in detail at page 535. The personnel is ordered to be distributed during action in the following manner: The surgeon-major in command, with 1 surgeon as an assistant, the sergeant-major, compounder, bugler, 1 sergeant, 1 corporal, and 4 privates (1 as cook), are to be at the dressing-station, while the quartermaster-sergeant and 6 privates are to be with the baggage and supplies in rear. Two of these privates act as company cooks. One sergeant is to be posted at the collecting-station; he is to have a medical field-companion in his charge. Two stretcher sections, each section consisting of 1 sergeant and 4 stretcher squads, or 16 privates, are sent out for carrying the wounded, under the charge of a surgeon. Five corporals and 5 privates are attached to the 10 ambulance waggons, 1 to each waggon. It must depend upon the nature of the engagement, and the character of the ground upon which it takes place, how far and in what way the distribution named can be carried into effect. It will depend upon the orders of the surgeon-major in command of the company, or upon superior authority, in what directions the ambulance waggons are to move. It may be that the first line of waggons will be used for bringing the wounded from the collecting-station to the dressing-station, while the second line is employed for carrying wounded from the dressing-station to the field hospital; or if the wounded brought to the collecting-station

are very numerous, both lines together may at first be employed for conveying them from the collecting to the dressing-station. The distance between station and station, the movements of the troops, and various unforeseen circumstances, will always influence the decision on such points when once an action has commenced. The main object to be kept in view is that the wounded who require carriage are to be conveyed as rapidly as possible to the dressing-station, and after having received the attention which their needs require, to be as speedily removed to the field hospital as they can be. All accumulation at dressing-stations should be obviated to the fullest extent possible.

It is to be remembered that the formation and service of the dressing-stations is not the only function of the bearer company, but that the succour and collection of the wounded on the field, and their conveyance to the dressing-station and field hospital, is also performed by it. The company is also held responsible for picking up the kits, arms, and ammunition of the men who are wounded, and of the care of these articles until they are given over to the field hospitals. To avoid imperfect co-operation, and to ensure direct responsibility, the whole control of the bearer company, when in action, is placed in the hands of the medical officer who is in command of it. He is answerable to the general officer commanding the division to which he is attached, and to the principal medical officer of the division, for its efficiency, and is under their orders. If, however, no orders have been received from these officers, the medical officer in command of the company, on his own responsibility, has to organise the collecting and dressing stations, and to take all such measures as may appear to him best calculated to ensure the most speedy relief and transport of the wounded.

Organised bearer companies do not exist in time of peace. They are only constituted for service in time of war. The only exceptions are when a bearer company is formed for purposes of instruction at the Training School of the Medical Staff Corps at Aldershot, or to join in peace manœuvres. When preparations are being made for war, on the orders being issued for the formation of bearer companies, the personnel of each company is to be assembled at the place of mobilisation, and it will be the duty of the medical officer selected for the command of the company to obtain by requisition the authorised stores and equipments (" Army Med. Regs.," Sect. II., pars. 664, &c.). The responsibility is thrown on him of being personally satisfied, and of reporting to the Director-General of the Army Medical Department, before the bearer company embarks for service, that it is complete in every particular, its personnel and equipment included. The transport conveyances and personnel are supplied by the Army Service Corps, and it is ordered that, if possible, they shall be embarked in the same

vessel as the rest of the company, and sail with the brigade to which the company is attached. If these regulations are duly carried out, each bearer company ought to land at the site of disembarkation in a complete state of readiness for active service. Each brigade of an army has one bearer company allotted to it, so that with three divisions, of two brigades each, of infantry, and one division of cavalry, in an army corps complete of about 42,000 troops, there would be eight bearer companies.

Field-hospital equipment to be stored ready for immediate use.—The whole equipment for the field hospitals and bearer companies, in proportion to the number of troops which the Government of a country may think right to keep prepared for moving into the field, should always be kept ready for use in time of peace. A great part of the equipment is of a special character, and cannot be obtained at very short notice. Unless this is done, there must always be some uncertainty respecting the possibility of procuring the necessary stores, and adequate transport for their conveyance, every time that an outbreak of war is threatened. I have seen the articles comprising the equipment of a given number of field hospitals, and the transport which would be necessary for their conveyance, all stored together in the magazines in Germany; so that, on a sudden declaration of war, the only orders necessary would be for placing a few articles of a perishable nature, such as medical comforts, in their respective cases, and to pack for taking the field. It is quite as necessary for efficiency to have the field hospital and bearer company equipment stored ready to meet a sudden emergency of war, as it is to have the fighting equipment ready; and there ought to be no difficulty in turning one out as speedily for service as the other, directly the order for doing so is issued. It has been stated that the arrangement just mentioned exists with regard to the equipment of a British force of the strength of an army corps, and that the equipment for a still larger force is ready for disposal if needed.

5. Posts of regimental aid.—These posts are arranged for affording such surgical help during an engagement as may be demanded for preventing speedy loss of life in particular cases, for preventing malingering, for obviating crowding, and for giving any directions to the bearers that may appear of vital importance to the sufferers, before they are carried to the collecting and dressing stations. Such posts are therefore placed closely in rear of the regimental combatants, and are provided only with the most limited personnel and amount of surgical matériel. Each regimental aid-post is under the direction of the medical officer attached to the regiment, assisted by a corporal and orderly. He has under his orders the trained bearers of the regiment, who are provided with the stretchers carried in the regimental transport. The surgical equipment is also of a very

limited character—generally only a field medical companion and water-bottles and a surgical haversack. Under occasional circumstances, the field medical and surgical panniers may be employed.

It is useless to attempt to arrange for the performance of any surgical operations of importance under fire. Not to mention numerous circumstances which deprive the surgeons of the power to perform them with adequate care, the wounded men themselves are not in a condition to be subjected to them. The one idea among those who retain their consciousness is to get themselves carried away from where they are to a place of shelter. The sound of every passing bullet is a source of fresh agitation. There is a vivid impression on the mind of every wounded man that delay will only lead to another wound, and that the next one will perhaps be fatal. There are none of the conditions, therefore, which ought to be present in a conscious patient who is to be subjected to a surgical operation. The stretcher-carriers under such circumstances are almost the only helpers desired or likely to be of service. It follows that the only cases to which surgical attention can be advantageously given at the regimental posts are almost exclusively those of patients who are in a state of dangerous collapse from loss of blood, and in whom the flow can be checked by instant attention. All who know what battle means are aware that the opportunities of affording this assistance are rare indeed; and considering how far more useful surgeons may be at the dressing-stations and field hospitals, it seems only reasonable and right that but very few indeed should be ordered to practise professional duties in such positions. It seems hard to say so, but the strongest argument, perhaps, that can be used for leaving any surgeons at all under fire, is that the knowledge of their presence affords some moral support to the troops who are engaged with the enemy.

The number of regimental posts must, like the dressing-stations, vary with the manner in which the troops engaged are distributed. Probably one to every brigade of three battalions will suffice; the surgeons of two of the battalions being sent to assist in attending to the wounded at the dressing-station.

The various posts for help to wounded in the field.—It will be seen that the modern system of surgical help to wounded men in the field embraces four establishments—viz., (1) help of extreme urgency at the place of conflict; (2) further slight help, if needed, at the collecting-station, where they are transferred to the ambulance waggons; (3) help of a more important, but still provisional character at the dressing-station; and (4) help of a definitive kind at the field hospital.

This number of posts for help is now essentially necessary, in consequence of the great range of rifle-shot and modern artillery

fire, and of the distance from the combatant line of troops at which this fire causes the dressing-stations to be established. On the one hand, it is necessary that the bearers should not have too great a distance to carry the wounded on stretchers from the scene of action, so as to be drawn away from the immediate rear of the combatants for too long a time; on the other hand, it is necessary to prevent the wounded from being too long without an opportunity of receiving surgical attention.

The four help-stations behind the combatants will then be—(1) the regimental help-station; (2) the collecting-station; (3) the dressing-station, and (4) the field hospital. The positions selected for these relief posts must vary in accordance with peculiarities of ground, the nature of the engagement, and many other circumstances, local and general; but some general guiding principles will always have to be taken into account in making the selection of them.

Position of the 1st help-station.—This will always be in the immediate rear of the fighting line, moving as the combatants move, whether advancing or retiring. The duties of this station must be performed more or less under fire: their nature necessitates this.

Position of the 2nd help-station.—This is the collecting-station, and its position has to be regulated by the following considerations:—It should be (*a*) sufficiently clear of rifle-shot from the combatant force opposed to the troops in whose service it is formed; (*b*) it should approach the front as closely as is consistent with the requirement just named, so that the wounded may be got into the waggons as early as possible, and the bearers left free to return to the front for more wounded; (*c*) it should be at a place practicable for wheeled vehicles, and (*d*) should be in ready communication with the dressing-station.

The first consideration (*a*) will usually require the position to be at least 1000 yards from the rear of the troops engaged. The range of infantry fire is now 2000 yards and upwards, and the distance just named behind the combatants will probably place the collecting-station clear of the enemy's fire. The second consideration (*b*) makes it important that this distance should not be exceeded. The third (*c*) and fourth (*d*), that the station should be close to a lane or road, or, in their absence, on ground as nearly level as can be obtained. It will be of special advantage if the collecting-station can be established in farm buildings or under any kind of shelter.

Position of the 3rd help-station.—This is the dressing-station. It should be (*a*) out of the range of artillery fire from the enemy; (*b*) at a spot easily reached by the wheeled vehicles, and on the road towards the field-hospital station; and (*c*) near an ample supply

of water, if one can possibly be obtained. The first requisite (*a*) will probably be met by placing this station about 1000 or 1500 yards in rear of the collecting-station; the second (*b*), by placing it at the side of a road leading to the village or place where the field hospital is stationed; the third (*c*), by selecting a site near a well, spring, or running stream. At the same time, as a water-cart forms part of the equipment of each bearer company, a fair amount of water should be forthcoming even though a natural supply may not be close at hand.

Position of the 4th help-station.—This is the station of the field hospital. It should be sufficiently far from the actual scene of conflict to be safe, in a considerable degree, from risk of being brought within the sphere of fighting—either in the movements of the troops while manœuvring, or in case of the division to which the hospital belongs having to retire. Probably no position can be taken where the hospital will be entirely free from these risks without at the same time in a great degree destroying its utility; but a prudent selection of site may lessen them very materially.

In respect to distance, from two to three or four miles in rear of the combatants will probably be found to be a necessary distance for the field hospitals. This will not be too far for communication by wheeled vehicles, and will generally be sufficiently safe as regards the wounded. Circumstances may render a distance of five miles, or even farther, from the place of fighting necessary for the position of the field hospitals, as was shown in several instances during the Franco-German war. The field hospitals should not be placed nearer than the shorter distance named, under any ordinary circumstances, with an attacking army. The accidental situation of a village, or suitable farm or country house, a good supply of water, the nature of the roads, especially in regard to facility of transport from the front, will often determine the choice of the locality for a field hospital. Behind the position of the field hospitals is the advanced depôt of medical stores, from which their stores can be replenished. No commanding position likely to become one of prominent strategical importance, no village that is likely to be occupied to shelter an advanced or a detached body of troops, or for any military purpose, should be chosen for the site of a field hospital. If possible, a situation on the main route followed by the troops should also be avoided, from its being likely to become encumbered and blocked by the numerous heavy vehicles of the army. At the same time a field hospital should not be opened far from the main route, or, should it be ordered to be evacuated, the power of readily removing its inmates to one of the stationary hospitals in rear may be impeded, and possibly there may be difficulties in

obtaining some necessary supplies. All these considerations show the necessity for military experience, as well as for knowledge of surgical duty, on the part of those on whom the duty devolves of making such arrangements.

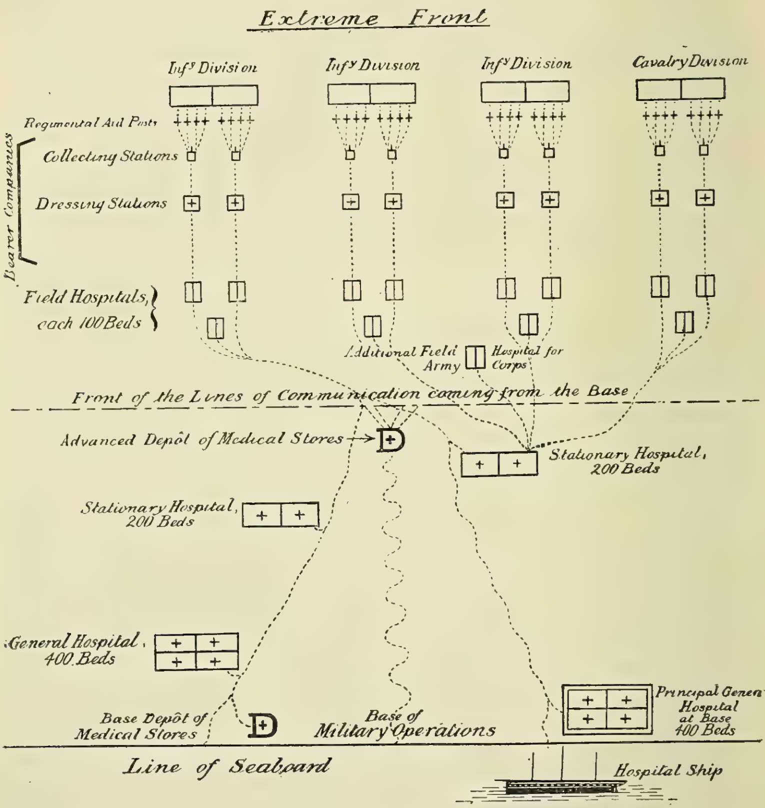
As before mentioned, such directions as are given concerning the positions of the surgical posts ordered to be established for the relief of the wounded must only be regarded, like many other regulated military dispositions, as being of the nature of general principles to be adapted to the special circumstances of each particular occasion. They are liable to be modified in practice according to the varying nature and extent of the military operations, the features of the terrain, the personnel and matériel at disposal, and other such matters. The principal medical officer of the division to which the field hospital is attached, who is charged with the responsibility, or his administrative representatives when they are vested with the necessary authority, must decide on all such arrangements.

The sketch on page 564 will serve to illustrate the number and distribution of the help-stations allotted by regulation to an army in the field, which have just been described.

6. **Field ambulance train establishments.**—During the time that a battle is in progress, and while some of the wounded are being attended to at the dressing-stations to which they have been carried, a constant conveyance of other wounded from the field is necessary. Those also who have been dressed must be taken in succession to the field hospitals. A constant circulation of transport is required all the time an action lasts, and so long as any wounded men require to be carried away. Subsequently the wounded who have been treated in the field hospitals, and who admit of removal, will have to be taken to the stationary hospitals on the lines of communication, and from these again, in due course, to the general hospital at the base of operations. These operations lead to the necessity for certain ambulance train establishments, consisting either of wheeled or pack conveyances conducted on ordinary roads, or of carriage conveyances on railroads. By whatever means the wounded are being moved, they require a certain amount of supervision and care during their removal; so that, for the time being, large ambulance trains, when they are conveying wounded, may be regarded as moving hospitals. The constitution of the field ambulance train supplied by the Army Service Corps has been shown when describing the composition of the bearer company. The vehicles composing this train are not intended to pass beyond the line of the field hospitals. As the essential purpose of all ambulance trains is the systematic and careful removal of the wounded from station to station, and as many of these men must be in a very critical condition, requiring skilled

care and attention while undergoing transport, it follows that such trains must not only comprehend transport vehicles with their drivers, but also a certain staff for affording surgical assistance. This help is given, so far as the field ambulance train with a bearer company is concerned, by the men of the Medical Staff

FIG. 55.



Sketch of Surgical Establishments allotted to an Army Corps of 35,087 troops, together with a Cavalry Division of 6700 troops, by Field Regulations of 1893.

Corps who form part of the establishment of the company. Either a corporal or a private of the corps accompanies each ambulance waggon. In the case of a convoy of wounded moving from a hospital on the line of communications by road, the necessary surgical supervision and help have to be provided by the medical officer in charge of the hospital from which the sick are removed.

The transport conveyances will be obtained on requisition from the Army Service Corps, but it is not provided that they shall be special ambulance waggons. Country vehicles may be employed for this service.

7. Railway ambulance train establishments.—When many wounded or sick soldiers are transported by railway, an establishment of surgeons and attendants, in proportion to the number entrained, must accompany them to minister to their wants in the carriages on the way and during halts at the provision-stations. What this establishment is to be, must vary according to the distance of the railway journey, arrangement of halting-stations, the kinds of carriages employed, the means of communication between them, and other circumstances. With the exception of particular instances in which specially constructed trains and well-organised establishments were engaged in the removal of wounded during the great civil war in the United States and the Franco-German war of 1870–71, the transport of wounded by railway has hitherto been usually attended with much suffering to them, and often with aggravation of their injuries. This subject has been well studied on the Continent of Europe, and many experimental trials have been made to determine the most appropriate forms of carriages and the best organisation for railway ambulance service. It will be again referred to in the chapter on Transport. I am not aware that any regulations have been issued in England regarding the management of railway hospital trains in time of war, although special and minute instructions are given in the Queen's Regulations and Orders for the Army on the entraining and detraining of troops of all arms of the service, including artillery, cavalry, and matériel, when moving by railway.

8. Hospital ships.—These vessels are of great importance as regards the comfort and welfare of sick and wounded troops, and they are always much needed when the enemy to be encountered is one at a considerable distance from our own shores. Hospital ships are arranged to accommodate both disabled officers and men: however comfortably officers may be provided for in passenger or hired vessels, they cannot be so well cared for, when requiring surgical treatment, as when they are placed in ships which are regularly provided with all the essentials of a hospital.

Hospital ships are especially useful for separating the sick from the healthy on board the transports at the first place of rendezvous, if this be ordered to take place while the force is on its way to the scene of military operations; for the reception of those who are too sick to land on the arrival of the force at its place of destination, if this be a hostile country; for the reception of casualties which may occur in effecting the landing itself; and for the periodical conveyance of the sick and wounded when a

sea intervenes between the field hospitals and the general hospital at the base of the military operations. They are also most desirable for the transport of wounded invalids who are incapacitated for further service in the field, and who are therefore ordered to be sent to England, either for treatment or for discharge from the army. A hospital ship may also be used with advantage as a *stationary* hospital when climatic or other reasons render treatment in a hospital on shore near the sea-coast objectionable, as was the case during the Ashanti war. It then assumes the characters of the principal general hospital at the base of operations, and it is now directed in the regulations for medical services that hospital ships may be employed not only to supplement, but also to act in lieu of, general hospitals on shore at the seaboard base of operations in time of war. When the invasion of the Crimea was undertaken, cholera was prevailing among the troops, both during the passage from Varna to the place of rendezvous of the fleet at Baldjik Bay, and from the latter to Kalamita Bay, where the army landed; and, on this account, properly fitted and equipped hospital ships would have been an invaluable resource. None, however, accompanied the expedition. Ordinary transports were afterwards used for hospital purposes, as well as for conveying the wounded from the Crimea to the principal general hospital at Scutari; but they were extremely ill-suited to the purpose. They were generally not sufficiently high between decks, not provided with the necessary fittings for the reception of wounded men, not clean, badly ventilated, and without proper attendants. The experience which was then gained has led to many improvements in this regard. The regulations now order that hospital ships are to be provided on all occasions when an army is about to take the field. By the Army Medical Regulations of 1890, each division of an army corps is to have a hospital ship, with steam power, capable of making up 200 beds, or, in an emergency, 250 beds, when such a vessel is considered necessary; and the hospital ship is to have a small steam-transport attached to it as a storeship, and carrying a supply of 400 canvas cots, available for being fitted into transports at the base of operations when additional hospital accommodation is required.

In the Chinese war of 1860 two hospital steamships were despatched from England fully equipped;[12] but since that date great improvements have been made in their construction and fittings. The most perfect and the most successful example hitherto afforded of a hospital ship was the *Victor Emanuel*, which was arranged and fitted, under the directions of Director-General Sir William Muir, for service on the west coast of Africa during the Ashanti war of 1873–74, and for transporting the wounded from that station to England. The organisation

and arrangements of this hospital ship scarcely admitted of any improvement.

The military arrangements in hospital ships include the provision of the necessary number of surgeons, hospital attendants, dispensers of medicines, and medical and surgical appliances—in short, a complete hospital establishment—for the proper treatment and nursing of the patients intended to be accommodated in them. The Admiralty undertakes everything connected with the conveyance of the sick, including fittings and bedding, and also for victualling them; and is therefore responsible for providing food, medical comforts, mess utensils, and cooks for them. Special accommodation is provided in these ships for the reception and treatment of sick and wounded officers.

Auxiliary hospital ships.—The regulations provide that, in addition to the hospital ships, there shall be one or more fast steam-vessels, each making up sixty beds, to be employed for taking the worst cases from the hospital ships to England or elsewhere. There are also to be despatch-vessels fitted with canvas cots, for taking less severe cases to any available packet station, and transferring them to mail packets which are on their way to England. Special arrangements will be made with the mail packets for carrying small numbers of invalids as passengers.

9. Permanent hospitals at home.—A description of the establishments for permanent hospitals at home will be found in the Army Medical Regulations. The wounded, as they arrive in England, may, if sufficiently recovered, be sent to the depôts of their regiments, but the majority will be sent to the invaliding hospitals at Netley and Woolwich. In case their accommodation should not suffice for all the invalids sent home, some of the larger station hospitals at Aldershot or elsewhere would be arranged for receiving them.

National Aid Societies.—In each of the leading countries of Europe, Great Britain excepted, there exists, in systematised official relation with the War Ministry, a National Society, mainly composed of civilians, for aiding the sick and wounded soldiers of the country in time of war. These societies are so organised as to be capable of affording very great assistance in hospitalisation and transport duties, as regards both personnel and materials, to the Government of their respective countries whenever they become engaged in war. The action of the National Aid Societies is voluntary, but is guided and restrained by regulations approved by the War Ministries, so that their members may work in harmony with the regular services for the welfare of their sick and wounded countrymen. In such countries they as much form part of the army medical establishments for meeting the exigencies of war, as the volunteer combatant forces in England do with regard

to the fighting arrangements for resisting invasion; the only difference being that the members of the National Aid Societies do not receive pay or remuneration from the Government, while the members of the British Volunteer Force obtain Government support. The official relations of the Continental National Aid Societies with their Governments and the military authorities give the members a title to the privileges conferred by the Geneva Convention. There is nominally a similar society in England, but it has no official connection with the War Department, is not bound by any exterior authority, while its organisation has been chiefly adapted for applying funds collected from benevolent persons to mitigate the sufferings of contending armies abroad. Its personnel would not be entitled to claim the privileges of the Geneva Convention so long as the society is not included in the official military establishments, to which alone the Convention refers. It is not necessary, therefore, to refer further to this society in the present work, which deals principally with the regular assistance that may be officially depended upon for the wounded of our own armies.[13]

Examples of hospital establishments in time of war.—One or two illustrations will serve to show more clearly the application of the hospital establishments which have just been described. The last British war in China occurred in 1860. The base of operations was Hong Kong, and the *principal general hospital* was established there. Here were left the sick and weakly men on the expeditionary force starting northwards, and to it invalids were subsequently sent from the force which was operating in the field. A stationary *intermediate hospital* was established in Talien-Wan Bay, where the force made its rendezvous before landing on the north coast near the mouth of the Peiho. The hospital ships in the mouth of the Peiho river afterwards formed a *second set of intermediate hospitals* on the line of communication with the base; and when the troops moved to Pekin, a *third line of hospital establishments* was formed at Tien-tsin. The movable *field hospitals* were with the army itself. Or, taking the Crimean war as an example, the *principal general hospital* at the base of operations was at Scutari, to which other subsidiary general hospitals were successively added at Abydos, Smyrna, and Renkioi; the *intermediate hospitals* were those at Balaklava, and at the monastery near the sea-coast, in the Crimea itself; while the movable *field hospitals* were the divisional and regimental hospitals within the limits of the camp and immediately before the besieged town. Occasional flying hospitals, which were collecting and dressing stations combined, were established in the ravines between the camps of the allies and the fortress. The sick and wounded were removed by ambulance trains, consisting either of wheeled

transport or pack conveyances, and part of the time by railway, from the field hospitals to the stationary field hospitals; from the latter by hospital transports to the principal general hospital at the base; and from this again by hospital transports to the general invalid hospitals in England.

During the Franco-German war of 1870–71, the arrangements were different from those just described, because the war was waged between two adjoining nations without an ocean intervening. The principal general hospital of the Germans was therefore established in a convenient position near their frontier, at Mannheim. As the armies advanced, intermediate hospitals became established, first at Saarbrück, and subsequently at various points along the lines of military operations. As the principal general hospital at Mannheim became speedily filled after the early battles, other general hospitals were opened. At the same time, as circumstances permitted, the hospitals at Mannheim were relieved from time to time of their accumulated patients. The wounded men were conveyed in detachments in different directions, according to their nationalities: if Bavarians, they were evacuated upon Munich; if Saxons, upon Dresden; and so on. In these operations railways took the place of the hospital ships employed during the Crimean war for the conveyance of the disabled invalids from the base hospital at Scutari to the home country. As the German armies advanced farther into France, and the sick and wounded increased in numbers, while the general hospitals near the frontiers were still largely occupied by patients, it was found more convenient, in many instances, to send large convoys of wounded men from the field and intermediate hospitals by organised railway ambulance trains to hospitals in Germany, without any stop at the general hospitals on the frontier, and with only occasional halts at rest and supply stations formed at intervals along the lines of railway. In some instances these journeys were of great length, as from Paris to Breslau or Königsberg. The hospital establishments with the German armies actually in the field consisted of the light regimental establishments, with the *Sanitäts detachements,* and *Feld lazarethe,* which are equivalent to the British bearer companies and field hospitals.

Under very exceptional circumstances, such as happened in Egypt in the war of 1882, the collecting and dressing stations may be united at one and the same spot; the wounded, after being attended to, may be sent to field hospitals at a moderate distance off in rear, and from them, with scarcely any delay, be immediately removed to the hospital establishments at the base. This Egyptian campaign, however, was unaccompanied by many of the conditions which prevail in European wars. It was the suppression of a military revolt by a British army in a foreign country, but the

country of an ally; the opposing forces were completely defeated at the first encounter on a large scale, leaving the British troops masters of the ground without any further serious attack being threatened from any direction; and the lines of communication by railway and canal with the base at Ismailia were open and direct. Thus there were no impediments to the wounded being speedily carried from the places where they fell direct to the general dressing-station established on the field; or, after their necessities had been suitably attended to, to their being sent on to the field hospitals opened at Kassassin Lock, and thence again, after a night's rest, the slightly wounded by railway, the severely wounded by canal, to the base itself. By these means, men wounded in the battle of Tel-el-Kebir, on the 13th of September, were in the hospital ship at the base, or sick-transports in harbour, ready to start for England or other destinations on the 15th, two days after the battle. Such a war can hardly serve as a guide for surgical arrangements in future wars in Europe.[14]

CHAPTER II

ARMY HOSPITAL ADMINISTRATION

Hospital administration in the field.—In considering the distribution of the various medical establishments employed in time of war, already described, and the manner of administering the professional duties which devolve on the surgical staff in connection with them, it is convenient to make a division of the subject in accordance with the surgical necessities of the wounded as they are likely to occur within particular sections of the sphere of military operations, and at different periods of time. Usually on the occurrence of war, when the military operations assume an extended character, the surgical service may be regarded as divided into three zones, each comprehending a certain number of lines, or stations, of help. The first zone of service comprehends the space between the place of fighting itself and the line of the movable field hospitals, and includes these establishments. The second zone occupies the space between the movable field hospitals and the general hospital at the base, which is included in it when the base is in direct communication and touch with the lines of communication extending to the army operating in the field. When the general hospital at the base is separated from the lines of communication, and a considerable distance intervenes between them, especially if this is by sea, as the hospital at Scutari was from the port of Balaklava, and the lines communicating with the

army before Sebastopol during the Crimean war, it rather belongs to the next, or third zone. The third zone comprehends all behind the theatre of active military operations in the field, and extends from the line of seaboard at the base to the permanent hospitals in the native country to which the troops belong.

Subdivisions of surgical service in time of war.—Owing to the insular character of Great Britain, the third zone of surgical service in the case of a British army operating abroad becomes practically divided into three distinct and separate lines of assistance—viz., (*a*) the seaboard line at the base of operations; (*b*) of the sea-transport homewards; and (*c*) that of the permanent invalid hospitals at home. The administration of each of these services, of the third zone, as well as that of the two zones in the field, must be separately considered by those whose duty it is to make the necessary provision for the wants of the sick and wounded of the army.

The surgical help given during the transport of the wounded from the front to the rear of each of these zones is so arranged as to belong specially to the particular zone within which the removals take place—in fact, to be independent, although in ready communication one with another. A special establishment for each zone, arranged in definite proportion to the amount of need, will not interfere with interchanges of the personnel, if circumstances render them desirable, so long as the numbers determined upon for each establishment are maintained.

The mode of administering the surgical duties in the first of these three zones will alone be considered in the present chapter. The administrative duties of the so-called stationary hospitals on the lines of communication closely approximate to those of all military hospitals, although they resemble the movable field hospitals in their limited establishments and lightness of equipment. The administration of the general hospital at the base resembles that of a permanent general hospital in England. Instructions on the manner of conducting the duties in these hospitals constitute a regular part of army regulations, as do also the rules for administering and conducting professional duties on board of hospital ships.

Administration from the fighting line to the field hospitals.—The responsibilities which devolve on the medical officers of an army on the occasion of battle are very onerous. The safety of the lives of many wounded men, and the future condition of many of those whose lives are preserved, depend to such a large extent on the manner in which the surgical duties are discharged, that it becomes most important that every medical officer should make himself acquainted with the principles on which they may be best conducted. It is not possible to lay down strict and absolute rules

of conduct for meeting the wants of the wounded. The circumstances under which battles begin, and under which they are carried on, as well as their results, are too various, and the changes which occur too sudden and too unexpected in their nature, for precision to be obtained in this respect. But if sound principles of action be established for meeting the most pressing necessities which usually occur on such occasions, these principles, if they are applied with judgment and intelligence, will generally meet the requirements of the wounded, however special the circumstances of an engagement may be, in the most effective way that is practicable.

The order of service to be performed in the first zone of surgical assistance will be, as before indicated—(1) to pick up the wounded; (2) to attend to any wants of extreme urgency; (3) to carry them to the collecting-stations, and from them to the dressing-stations; (4) to apply primary dressings, and administer all such relief to the wounded as can be afforded quickly; (5) to remove the patients when temporarily dressed to the field hospitals, and (6) there to supply definite hospital treatment. As the first part of this service must be rendered within the fire zone and at much personal risk, only very steady, active, and well-trained bearers can be depended upon to perform it.

Surgical preparations at the commencement of action.—In whatever way a battle may be brought about, as soon as the attacking troops quit the close order in which they will probably have been previously marching, and begin to deploy and to form an extended front, the surgeons attached to regiments, acting under the general direction of the divisional principal medical officer, and the men of the regiment trained to act as bearers of wounded, should fall to the rear—if they have not already become occupied through some of the troops being wounded by random shot while advancing—and should at once prepare for their respective duties. It is ordered in the Queen's Regulations and Orders for the Army (Sect. xiv., pars. 66 and 67), that when an action is about to begin, the trained regimental bearers, with the field-stretchers which are carried in the regimental transport, are to be placed at the disposal of the medical officer attached to the corps, and to act under his orders. The bearer company must also without delay get ready for discharging its special functions in rear of the brigade or division according to orders. At the same time, suitable positions will have to be taken up in rear of the troops for the field hospitals, some of which must be unpacked and got ready for the reception of the wounded. Regimental stations of help will probably have to be established in the first instance, some of the surgeons attached to the regiments working them with such means as they have at hand. The regimental

bearers, having got their stretchers from the carts, and having deposited their knapsacks, fire-arms, and accoutrements in them instead, will without delay proceed to carry the wounded to the collecting-station.

One of the regimental surgeons at least should be told off to remain in the immediate rear of the fighting line of each brigade, ready to attend to cases of extremely urgent need, such as the temporary arrest of dangerous hæmorrhage, and also to forward the continued removal of the wounded. The other regimental surgeons might be advantageously detached to help at the dressing-stations. If the regiments be spread out in very extended order, it may be considered necessary for a surgeon to remain in rear of the fighting line of each regiment. The principal medical officer of the division is responsible for such points of duty being arranged and attended to.

The preparation of the bearer company consists, in the first place, in determining the sites of the collecting and dressing stations, and in marking their positions by the regulation flags, so as to indicate the spots selected to all concerned. The collecting-station is the place to which the wounded carried on stretchers are brought by the bearers, and at which they are to be transferred to ambulance waggons for removal to the dressing-station. If circumstances admit, it should be near a road, and under shelter if possible, and not too far from the rear of the fighting line, in consideration of the fact that the wounded have to be carried by hand to it. A sergeant, according to existing regulations, is to be posted at this station; no mention is made of a medical officer. The sergeant is to have a water-bottle and medical field-companion with him, as well as a reserve of bandages and first field-dressings, to take the place, if needed, of those which the bearers have used out of their haversacks.

The dressing-station is formed at the spot selected by the medical officer in command of the company. The ten ambulance waggons of the company are drawn up in two lines, ready to start to any part to which they may be ordered; a waggon orderly of the Medical Staff Corps being in attendance with each waggon. The operating-tent is pitched if there is no available shelter of a fixed description, the surgical equipment is unpacked, and placed handy for use; the field-panniers are brought into the tent and arranged as an operating-table; the staff of the dressing-station, before enumerated, take their respective positions; the cooks get some beef-tea prepared, and have hot water ready; a proportion of the ambulance waggons is ordered to the collecting-station to await the arrival of wounded, while some remain at the dressing-station ready to convey the patients, after being attended and dressed, to the field hospital. One of the earliest proceedings will be the despatch, under the direction of a surgeon-captain, of the

two stretcher sections to collect and carry wounded men to the collecting-station.

The foregoing is an outline of the authorised instructions for the disposal of a bearer company on the approach or commencement of an engagement with an enemy. More detailed information will be found in the Manual of Instructions for the Medical Staff Corps. (See Sect. ii., Chap. ix., on Field Training.) It will be seen that the whole bearer company is contemplated to be moving as a compact body in rear of the brigade to which it is attached, up to the time the action is about to commence, and that none of the personnel of the company or of its equipment has been moving among the combatants in their various formations on the line of march. Up to the time of the action becoming general, any casualties that may occur, therefore, could only be attended to by the trained regimental bearers. They alone, too, would be available for the carriage and removal of wounded from the ranks to the rear.

The preparation of the field hospitals consists in unpacking and getting everything ready for the reception of patients; for the performance of surgical operations; for the application of definitive dressings; for the administration of food; and in making provision for all other probable needs of the wounded.

By the previous regulations, a field-inspector, acting under the directions of the principal medical officer of the force, was responsible for seeing that the preparations just mentioned were properly made all over the field, and for watching that the service was regularly executed afterwards. Now the office of field-inspector no longer exists; but each divisional principal medical officer, acting under the authority of the general officer commanding the division, is responsible for such supervision. It is his duty to advise with the surgeon-majors in charge of the bearer companies as to the positions of the collecting and dressing stations of the division; with the surgeon-majors in charge of the divisional field hospitals as to their positions and movements; and to see that the communications between them and the dressing-stations are properly maintained. The regulations direct him personally to supervise the performance of the whole of the surgical duties of the two brigades of his division within the first zone of assistance. If the divisional principal medical officer, from any cause, does not give the necessary orders on these subjects, the officers in charge of the bearer companies and field hospitals must arrange the positions of their respective establishments on their own responsibility.

Early casualties.—Isolated casualties may be expected to occur from long-range shot or shell on the advance of troops towards an enemy before they have assumed an attacking formation. They may happen at such a distance from the place

where the fire of the skirmishing troops commences as to be outside the lines of the dressing-stations which may be subsequently formed after the troops have moved farther forward. Such cases must be attended to at first by the surgeons attached to regiments, but should be handed over as speedily as possible to some of the staff of a bearer company, so as to set the regimental surgeons free for returning to their regiments. The bearer company must arrange for the removal of the wounded men to the field hospitals. If, however, these casualties have not occurred at too great a distance from the front, fresh cases as they occur among the advancing troops may be brought to the same spot, and, other circumstances rendering the place suitable, the bearer company may establish it at once as one of the collecting or dressing stations for the division to which the company belongs. Every regimental surgeon must make efforts to keep up with the regiment to which he is attached while it is advancing; it is ordered in the Field Medical Regulations that surgeons attached to regiments are never to lose touch with them.

Occasionally, even when at a remote distance from the enemy, a multitudinous rifle fire may be so directed that showers of projectiles, as it were, will pour upon the advancing troops, and then the men may fall so rapidly, and in such great numbers, that adequate surgical assistance is impossible. The fact that 6000 officers and men of the Prussian Guards, or a third of their total number, were killed or wounded in ten minutes under the fire of a French brigade at St. Privat at a distance of 1500 yards during the Franco-German war is well known; and in Demangel's work on Tactics (4th edit., 1887, p. 119) it is stated that during the Russo-Turkish war the Russians in many instances suffered losses from unaimed fire at 3000 yards, while cases often occurred of divisions of 10,000 men losing half their numbers at one mile from the enemy. It is hoped that improvements in the tactical disposal of troops may cause a repetition of such wholesale slaughter to be scarcely possible; but still there remains to be seen the effects of recent increments in the power and range of artillery, of the wider dispersion and increased force of shell fragments, and of the existing means, surpassing all former experience, of raining rifle projectiles among advancing bodies of troops, in whatever formation they may move.

Again, in assaulting particular positions, and on all occasions when large bodies of troops are acting against each other at close quarters, with the means which are now available, from the use of magazine weapons and machine guns, for increasing the intensity and rapidity of shot discharges, the wounded will often fall in such excessive numbers, so heaped together, that all hope of affording effective surgical aid to them is dispelled, because

it is rendered impracticable. Succour can only be given to the survivors after the fighting has ceased.

It is a lamentable truth which has to be faced, that in European warfare with the armaments of the present day, whatever surgical arrangements may be made, whether in respect to administration, personnel, or equipment (which, although relatively very limited in quantity, is even now by many officers regarded as too bulky to be compatible with military necessities in the field), effective surgical help can only be given at an early period of their wounds to a very limited portion of the officers and men to whom such help would often be invaluable and life-saving. The impediments in the way of early help being afforded to all are insuperable. Surgeons may strive to their uttermost, as they certainly will do, to save life and to lessen the sufferings of the wounded, but even with the best exertions they can devote to the work, the number who can benefit by their aid must be very short of the number who require it. It is one of the irremediable calamities of war, and the reflection that it is so ought to make war itself the very last of the last resorts of every civilised nation.

Difficulties of surgical administration from recent changes in fire-arms.—In addition to the difficulties due to the aggregation of wounded on occasions such as have just been mentioned, other impediments in the way of affording speedy and efficient surgical aid depend on the changes in tactics which have been rendered necessary by the alterations made during the last few years in military weapons, especially from the introduction of magazine rifles. The great disproportion in the losses among the troops at different parts of a field of action in modern European warfare, and especially the large numbers that fall on some portions of the ground, often widely apart, within brief periods of time, create special difficulties in surgical administration. The great lateral extent, too, now frequently taken by the troops in front, and the whole formation of the fighting line, are other impediments to early surgical assistance. Instead of the comparatively compact column formations to which foreign armies used in former days to adhere under ordinary circumstances, and of the two-deep line formations of the British army, the tactics of the present day tend to the dispersion of flights of independent skirmishers in constant movement over a wide and extended area up to the time of the final rush—the men, for the time being, though not separated so far from one another as to cease being under the control of their officers, yet acting almost individually, either concealing themselves for the moment under any available shelter, or running forward, or extending outwards, as the case may be. When any of the skirmishers fall badly hit under such circumstances, they cannot be got at, or at least cannot be got at until the troops which are engaged have passed beyond the ground on which the

wounded men have fallen. Evidently, therefore, if they are unable to make their own way to the rear, the men who have been wounded must remain where they have fallen, or under any shelter they may have been able to reach, until the ground has become clear through the advance or other movements of the troops. It would be folly to subject the lives of unwounded men, whose services are much needed, to the extreme risks to which they would be exposed in an attempt to remove wounded men while still under the fire of the enemy, even if there were not other objections, which there are, to making the attempt.

Successive stages of surgical help.—But many wounded men among the fighting troops are not thus altogether out of reach during an action. To these every help should be given as speedily as is practicable. When the several help-stations, previously described, are in working order, assistance will be afforded in the following way. The badly wounded that can be got at are picked up by the regimental bearers, or by some of the bearers of the bearer company, and carefully placed on stretchers. They are then carried for inspection by the surgeon attached to the corps to which the wounded men belong, if he be within a convenient distance; or if it would take up too much time to do so, are carried direct to the collecting-station. The bearers, on reaching this station, lay the wounded men down on the stretchers on which they have brought them from the field, take the stretchers from the waggons, or other vacant stretchers placed ready for the purpose by the bearer company, and return to the troops in action for more wounded. An experienced non-commissioned officer of the Medical Staff Corps is placed at the collecting-station to superintend the transfer to the ambulance waggons, and to give any directions that may appear to be needed to the privates who are told off to accompany the wounded men in them. The wounded are then removed in the ambulance waggons as fast as they can be to one of the dressing-stations.

On arrival at the dressing-station the wounded men will be examined in turn by the senior surgeon present, or by a surgeon told off for the purpose, and disposed of according to the nature of their injuries. Those requiring immediate surgical operations, as amputation, ligature of arteries, adjustment and support of fractured bones, should be placed in one category; those only requiring simple dressings in another. Mortally wounded men should be placed where they will be least disturbed, and their condition rendered as easy as possible. The surgical duties should be distributed among the staff and attendants in such a way as to ensure the duties being done as systematically, efficiently, and as quickly as the staff and means at disposal will permit. The surgeon who receives the cases as they arrive ought to mark those which require the earliest attention, and give the

necessary directions accordingly. As soon as the wounded have received whatever preliminary operative interference, dressings, or surgical attention their injuries urgently need, their specification tallies (see equipment, page 602) are filled up, and those who are unable to march are sent on as regularly as possible in the appointed ambulance waggons to the field-hospital station. The slightly wounded are sent to make their own way to a field hospital on foot, or by any conveyances that may be available for the purpose. If no preliminary attention be required although the men are badly wounded, they may be moved on in the same ambulance waggons in which they have been brought, without any delay at the dressing-station beyond what has been necessary for examination. When the wounded are given over to the field-hospital establishment, the men of the bearer company and the vehicles should return as fast as practicable to the dressing-station for more patients. Active supervision on the part of the officer or warrant-officer who commands the detachment of the Army Service Corps attached to the bearer company will always be required to ensure the regular conveyance of the wounded from the field to the dressing-stations and field hospitals, and the return of the men and vehicles from the rear to the front, being maintained without any undue interruption.

If the army be advancing steadily, and there is every prospect of the ground it has gained being retained, not only the surgeons occupied in the immediate rear of the combatants should move forward with the troops, but it may become necessary to advance the collecting and dressing stations also. If there are wounded waiting for attention or removal at these stations, they should be dressed and despatched to the field hospitals with all possible speed, to enable the stations to be advanced towards the combatants. If the number of wounded requiring attention at the dressing-station do not admit of an advance taking place, some surgeons and attendants with the necessary materials must be sent forward, and a fresh dressing-station be established in a suitable position. This, as well as all other details of movement and action of the bearer company, must be arranged by the surgeon-major in charge of the company, subject to the approval and direction of the chief divisional medical officer if he be within reach. If, however, in case of an advance, the stations could only be placed in some objectionable position, they must perforce remain where they have been already working, notwithstanding that the time occupied in the transport of the wounded from the field will be proportionately increased before they can be brought to the dressing-stations for their wounds to be attended to. If circumstances allow a section of one of the field hospitals to be advanced at the same time, it will be an advantage, supposing the military movements are not interfered with by the move.

No accumulation of wounded men at a dressing-station should ever be permitted to take place if it can possibly be avoided. Whenever practicable, the removals to the rear should be as continuous as the arrivals. If transport cannot be obtained for the purpose, and it is getting late, it may be necessary to keep wounded men for the night; but under any circumstances the dressing-station must be cleared of all wounded the day after an action. Each bearer company should be free and ready to move whenever the body of troops to which it is attached may make an advance.

If the engagement should happen to progress unfavourably, the army will probably have to retire—perhaps to retreat altogether, and as the issue of events in war is always more or less uncertain, it is necessary to be prepared beforehand with a general plan of conduct to meet each variation in circumstances, as it arises, in the best way practicable. It is the uncertainty just referred to that makes it an object of such extreme importance continually to pass on from the front to the rear, as rapidly as possible, all wounded men that are able to bear removal. If this rule be not attended to, and a retrograde movement have to take place suddenly, confusion will almost certainly occur; and many lives will probably be sacrificed, which might, perhaps, have been saved under better management.

If the army should suddenly have to retreat, all the wounded at the dressing-stations that can be conveyed should be brought away. They should be directed towards the nearest field hospital. If the troops should fall back as far as the field hospital itself, no attempt should be made to move this establishment, for the move could only be effected with great positive injury to very many of the wounded in it. It should remain stationary, part of the surgical staff and surgical equipment being told off to stay with it. The staff necessary for attending to the wounded patients will be able to continue the exercise of their functions, and both they and the wounded will be protected by the articles of the Geneva Convention, the terms of which international treaty are given *in extenso* in the Appendix. At the same time, all ambulance vehicles that appear capable of moving with the retiring troops should make every effort to do so, in order that their services may remain available in case they should be required for fresh wounded among them.

None of these arrangements should, however, be made by the surgeon-majors in charge of the bearer companies or field hospitals independently, unless very urgent circumstances compel them to do so. They should wait for instructions from the divisional surgeon-general, whose special functions are to keep a watchful eye on the progress of events, to observe the necessities of the various hospital establishments, and to issue directions in accordance with them.

When an action is concluded, a systematic search of the battle-

field and its vicinity should always be made for any wounded men who may still be lying on the ground. A few medical officers and non-commissioned officers of the Medical Staff Corps, with bearers under their orders, should proceed by the shortest way to the scene of action. Ambulance waggons should be near at hand. The bearers should be so disposed as to be able thoroughly to examine not only the open ground, but also any woods, ruins, ditches, or other places to which wounded men might be likely to move for shelter that may happen to be in the neighbourhood. Lanterns should be used when an action has not ceased until daylight has disappeared. The importance of this duty, and some of the points to be attended to in discharging it, have been elsewhere referred to.

Hospital administration on particular occasions.—The regulated system of army medical administration for relieving the necessities of the wounded, so far as general service in the field is concerned, having been sketched out, the administration needed for a few special occasions in time of war may be noticed. They can only be very briefly adverted to. The needful arrangements when a force is ordered to embark with the intention of effecting a landing on an enemy's coast, when a force is on the march, when troops are engaged in siege operations, and on the occurrence of a home invasion, if such should ever be attempted, will be successively glanced at.

Administrative arrangements on a force starting from England.—Before an army starts on a hostile expedition, the surgical staff and the surgical establishments of the force, with their equipments, will have been completed in accordance with regulations previously explained. The coast upon which the troops are destined to land may be near or distant. If near, as across a channel, the troops will probably be carried on the decks of steamers, or in open vessels towed by them. If the coast be distant, as across an ocean, the troops will be sent in regular troopships or hired transports, and probably land in the first instance on some colonial dependency, or in the territory of some friendly power, at no great distance from the point to be attacked. The military object of this preliminary landing is that the whole force may be assembled and marshalled together, and that the final dispositions for moving in concert may be settled. It will be convenient to consider the surgical proceedings in case the troops have to land in a distant country, as they will include most of the arrangements for landing on a coast comparatively near at hand.

Although the duties of the medical department connected with the preservation of the health of the troops are not described here, it must not be supposed that their importance is underrated. Nothing can be more essential, even as regards the recovery of men who suffer from gunshot wounds in the field, than that their

constitutional vigour shall be maintained as fully as possible up to the time that they happen to meet with their injuries. The fitness of transports for the troops to be carried in them, the manner in which hygienic regulations are conducted while the men are on board, as well as while they are on service in the field, all have an important influence on the results of the wounds and injuries to which they may afterwards be subjected. But definite regulations concerning these matters already exist, and need not be repeated in this work.[15]

When an expeditionary force has been collected at a place of rendezvous, and the final preparations for its start have been completed, detailed orders are usually issued for the information of every corps and department concerned in it. These orders include instructions regarding the positions and duties of all the officers and men employed in the expedition. The orders for the embarkation of the divisional and brigade medical officers will probably direct them to proceed on the transports detailed for the staff of the division or brigade to which they are attached; the bearer companies and field hospital establishments, to embark on the transports which carry their respective stores and equipment. Supernumerary medical officers will probably take passage in the hospital ships, while the medical officers attached to regiments will accompany their respective corps.

It is the duty of each medical officer in charge of a corps or detachment of troops, on embarking, to send to the principal medical officer of his division a *numerical* return of the officers and men embarked, and a *nominal* return of any sick that may be left behind, specifying their ailments, and to whose medical care or to what hospital they have been transferred. The returns thus furnished by the medical officers with the troops are tabulated and forwarded to the principal medical officer of the army. It is only by these means that he can learn correctly the distribution of the troops composing the force, and furnish the general commanding with information respecting the changes from disease and injury among them. In like manner, on completion of the voyage, a return has to be furnished, showing any changes that may have taken place from sickness or injuries in the interval.

Arrangements when landing in an enemy's country.—On the arrival of the force at its place of final destination, the disembarkation and landing of the troops may be opposed by an enemy in front; or it may be unopposed, as when a landing is effected at some unexpected point at a distance from a place where the enemy has taken up a position of defence.

Should the landing appear to be likely to be resisted, it becomes the duty of the medical officers, each in his particular sphere, to make preparations for the care of the wounded they may have to attend to. Surgeons attached to corps should have with them

the orderlies who carry the medical field-companions, and some dressings ready for use. Everything should be got ready on the hospital ships for receiving wounded, and for the surgical operations which may have to be performed. Care should be taken that the boats appointed to carry the wounded from the beach to the hospital ships are furnished with an ample supply of fresh water and vessels for drinking purposes. There should also be lanterns at hand, in case the wounded have to be conveyed at night-time. Some ships' cots will also be useful as conveyances. If practicable, large boats should be obtained for such duties, and they should be furnished with mattresses on which to place the wounded, and with blankets as coverings for them.

If the landing be secured, the removal of the wounded to the hospital ships or sick-transports may be managed with comparative ease; but in case of the attacking force meeting with a repulse, and being compelled to return to the ships, the duty must always be a very difficult and trying one. The wounded will have to be brought off with the least possible delay under cover of the guns of the ships, and the utmost presence of mind on the part of the medical officers will be necessary to perform their part in the operation with due regard to the necessities of the officers and men who have been seriously injured. If, however, the enemy be driven away and the landing of the troops secured, there will be no difficulty in establishing temporary dressing-stations on or near the shore. Two objects should be kept in view in selecting the positions of the dressing-stations on such occasions: one, facility of bringing the wounded to them from the place of fighting; the other, facility, after dressing, of carrying them to the boats for removal to the hospital ships.

The duty of collecting and dressing the wounded, and removing them to the boats, will principally devolve on the staff of the bearer companies. Some of the staff destined for service in the field and rear hospitals, and as many of the hospital-ship staff as can be spared, may be rendered useful in attending to the wounded during their conveyance in the boats to the hospital ships. It is not likely that further assistance will be required; but, if it be, some of the naval surgical staff will probably be available for it. The wounded should be got on board the hospital ships as speedily as possible. The troops, after effecting a landing, will probably lose no time in moving forward and taking up a position at some distance from the beach, and the battalion medical officers will be required to be with them. If the landing be thoroughly secured, and so decisive a victory obtained over the enemy that they retire altogether, then all the regulated surgical equipment should be sent on shore. The whole of the bearer and field hospital establishments for the active portion of the army should be completed and got in order without delay, so as to be able to join the force,

and to be ready to move with it, whenever the order for an advance is issued.

As soon as possible after the engagement, as on all similar occasions, *returns of casualties* should be made out and despatched to the principal medical officers of divisions by all medical officers attached to bodies of troops. The casualty return consists of a nominal roll of all the officers, non-commissioned officers, and men of the particular corps concerned who have been injured, with a terse description of the kind of injury received, and its degree of severity. Similar returns should be furnished from the hospital ships to which the wounded men have been taken, to check and supplement those furnished by medical officers attached to particular corps.

If it be intended to maintain a footing at the place of landing, and to keep up communication between it and the army, a stationary field hospital with its regular staff may be at once established there. If any suitable buildings are available, they should be at once secured, if possible, for the hospital. As soon as this is achieved, if there are only a few wounded on the hospital ships, and the ships are in an open roadstead, the wounded should be brought ashore to the hospital, in order to avoid the inconveniences which they might suffer in case of stormy weather. If, however, a hospital ship be full of sick and wounded, it should be despatched to the general hospital at the site from which the expeditionary army started, or to any other station ordered by the general in command, with orders to return immediately after transferring the patients to that establishment. Every care should be taken to enforce the speedy return of a hospital-ship when it is sent away; circumstances may lead to the hospital at the base having to be evacuated, or an increase in the number of wounded may occur suddenly from some fresh engagement with the enemy. The army having secured its footing on shore, the troops may either remain for a time to fortify their position, or a brigade or division of troops may be left, while the main body of the army moves forward. The medical officers who remain with the troops left behind under such circumstances will always find the exercise of their hygienic functions one of the most important, if not the most important, part of the duties which devolve on them.

On this, and indeed on all occasions when troops remain stationary for a time during a period of warfare, wherever a general hospital is established, surgeons should never let any opportunity be lost that may offer itself of practising the principal operations of surgery on the dead body. Nothing passes from the mind so readily as details of anatomy, or from the hand as dexterity in the performance of intricate surgical operations; nothing is so difficult, under ordinary circumstances, for surgeons in the army to obtain as opportunities of refreshing their knowledge, and of exercising

their abilities by practice in this branch of their profession; and yet how essentially necessary this knowledge and dexterity become on occasions of battle! The preservation of the lives of many of the wounded, and the future welfare of those among them who survive, will often materially depend upon the practice of performing surgical operations on the dead body having been followed, much more so than seems to be generally understood, or at least acknowledged. Moreover, the information and dexterity acquired by such means will be sure to prove a source of satisfaction to the surgeons themselves when they have to perform similar operations on the field or in the field hospitals; and, at any rate, will save them from the mortification, elsewhere noticed, of being restricted from acting in this branch of their profession. It will always be better for such exercises to be systematically carried out under the supervision of a competent and experienced senior surgeon, than for them to be resorted to by surgeons singly and independently. The staff of the bearer companies and men of the Medical Staff Corps with the field hospitals should at the same time be regularly drilled by the officer in charge in unpacking and loading quickly their respective equipment vehicles; in putting up, striking, and repacking the tents; in familiarising themselves with the contents of the surgical and medical cases, and their arrangement. They should also be practised in the various modes of lifting up wounded men according to the nature and situation of their injuries, placing and carrying them upon stretchers, applying provisional dressings and tourniquets, and, in short, in all duties bearing on the care and handling of wounded soldiers which they may have to perform. Although they may have been already instructed in these duties, frequent practice is essential for that ready and skilful execution of them which is of such extreme importance in the midst of the exciting circumstances under which they have to be practically applied in the field.

Arrangements with troops on the march in time of war.— Railways are now so generally distributed throughout Europe and elsewhere that it will probably be endeavoured, for purposes of readier transport of matériel and troops, in all future military operations on a large scale, to land near, and rapidly secure possession of a railway before the enemy can break up the line. But the movement of men and guns by ordinary vehicular roads must always be resorted to in the endeavours to place a force in the position which is considered the most eligible for the military purpose in view, whether it be one of attack or defence. When an army, or the main body of an army, has effected a landing in an enemy's country, it will be soon afterwards ordered to advance; and some of the arrangements necessary before starting, and during the march, will now be considered.

Before a march commences, particularly if the troops have been

encamped for some weeks near a town, a health inspection should be made by each surgeon in medical charge of a body of troops; and all men who labour under any physical ailment, or who appear from any cause incapable of continued marching at the required rate, and so to become inefficient, should be separated for the observation of the divisional inspecting surgeon, with a view to their being left behind for treatment. No really ailing men should be taken on; they will only lead to subsequent difficulties. The ambulance vehicles should not be used for men who are merely fatigued, but should be reserved for those who may casually become badly disabled during the march. Nominal returns of all men left behind must be sent in to the commanding officer and to the principal medical officer, through the usual channels.

The force may be ordered to march along a single road, or by separate lines or roads. If by several roads, the columns will be timed to arrive at some given point together. If the union of the several columns be successfully accomplished, there will be no particular difficulty in medically arranging for casualties, should an action occur; the general plan of help in the field will be carried out. But if the union is not effected as designed, and the advancing columns should be separately attacked, the difficulties of the medical departments in meeting the wants of the wounded will be excessive, and will only be overcome by the exercise of much energy and intelligence. The positions with the columns of troops of the bearer companies and field hospital establishments have been already alluded to (see p. 555). When the enemy is near at hand, it is essential that they should be so placed as to be able quickly to assume the positions which they would have to occupy in case of a battle being fought. Under ordinary circumstances the treatment of men falling sick or hurt will, in the first instance, be given by the surgeons attached to regiments and corps, but afterwards by men of a bearer company; and if it be necessary to remove them to the rear, they will be carried by some of the ambulance conveyances to the most advanced or nearest field hospital.

Before starting on the march, it is a good plan for regimental surgeons to provide themselves with small pieces of paper, on each of which is written the date, signature, and the words 'Permitted to fall out,' or some similar remark, to show that the bearers of such papers have been medically inspected. When a man is disabled from marching by sudden illness, he has to obtain the permission of his captain to leave the ranks. A non-commissioned officer will usually bring him to a surgeon, who administers a little medicine if that is all that is required, or should the man be found unable to proceed, gives him one of the papers just referred to, or *sick-tickets* as they have been called.

The man then waits by the side of the road until one of the ambulance waggons of the bearer company with a vacant place comes up, and the sick-ticket is the authority for his being carried upon it. Such patients, according to the nature of their cases, will either be discharged from duty in the ranks, or transferred to the care of that portion of the medical establishments which is under the immediate direction of the officer in charge of the line of communication between the army and its base of operations.

The names of all men received and carried in the ambulance waggons should be properly noted. They should appear in the daily state of sick, even though they may be well enough to resume duty on their arrival at a camping-ground, and to proceed on foot the next morning. Such cases will be recorded as 'admitted' and 'discharged' on one and the same date. An ambulance waggon, while moving with troops on a line of march, is to all intents and purposes a movable hospital. It should never be employed for the carriage of stores, or of any persons or articles other than those for which it has been specially designed and provided. When unoccupied by sick and wounded men, it should be kept vacant and ready for their reception, on the same principle that the wards of an established hospital are retained, fully equipped for use, when there are no patients in them. But unless the most stringent orders on this subject are issued by the highest authorities, and steps taken to ensure implicit obedience to them from all concerned, experience has sufficiently shown that these vehicles will not unfrequently be wrongly diverted from their intended purposes, and sometimes will meet with damage, affecting their subsequent fitness for ambulance service as a consequence.

If the army is marching without tents, pickets are posted as a matter of course when the troops bivouac for the night. As it must almost always be uncertain whether an attack may not be made by the enemy, the officers in charge of the pickets and of the bearer companies should be mutually acquainted with their respective positions, in case the need should arise for removing and attending to wounded. If the pickets are very strong, a surgeon and a certain number of bearers with stretchers will probably be posted with them.

One of the last things at night that each executive medical officer with troops should do, is to ascertain exactly the position of his personal case of instruments, and of his orderly with the medical field-companion, so that he may be able to have recourse to them in a moment, even in the dark, in case of a sudden alarm.

It is presumed in the foregoing sketch that the communications of the army are kept open with the base from which the march commenced. It is understood that the maintenance of the lines of communication, and of all departmental movements along

them, is placed under the command of a special officer with a competent staff to assist him. It will become the duty of the principal medical officer on the staff of this commanding officer, to submit to him for approval the places along the lines of communication which may appear most suitable for the establishment of stationary field hospitals, the arrangements that may appear desirable for the transport of the sick and wounded to them, for their removal by railway to distant hospitals, for bringing convalescents up to the front, and all other medical concerns behind the main body of the army operating in the field.

If a force be moving independently, all who become disabled must of course be carried with it, unless, when moving near a coast, there may happen to be an occasional opportunity of removing them to hospital ships or to other vessels.

Administrative arrangements on the approach of a general action.—If an enemy is about to be met in force, and it is sufficiently evident that a general action will be fought, the field hospitals, every available surgeon, and all the transport conveyances for the removal of wounded, should be brought up as near to the front as practicable. If the regulation transport taken with the force at starting can be supplemented by carts and animals requisitioned from the inhabitants, and these can be turned to account as a further supply of sick-carriage, they will prove a very valuable acquisition.

If the army has been marching independently, only the surgeons who have accompanied it can be present, unless, as happened at the battle of the Alma, being near the coast, additional surgical assistance can be obtained from vessels of war. In such a case the services of the naval surgeons who may be landed will be turned to best account if they are instructed to act for the time under the directions of the principal medical officer of the army, in order that he may dispose of them where they are most required. If, instead of marching independently, communication has been kept up with a base of operations, and the prospect of a battle being fought has become apparent in time to afford the opportunity to give the necessary orders, every medical officer not actually required in the hospitals in rear should be sent forward, as a temporary measure, to the front. They will not only be useful for assisting in the field surgical duties, but will be required for accompanying the wounded who may have to be sent to the rear afterwards. So also, for similar reasons, all hospital attendants that can be spared for a short time from the hospitals on the lines of communication with the base should be sent on for duty to the front.

Now is the time, when a great battle is about to occur, that surgeons will most thoroughly appreciate the advantages and personal satisfaction of having properly prepared themselves for

meeting their professional responsibilities by real and honest practical study, and by having made themselves acquainted with all the details of the surgical appliances at their disposal; just as it is the time when those who have not done so will feel most keenly the painful situation in which they have become placed from their previous neglect. Shortly after a battle has commenced, surgeons usually find themselves surrounded by so many wounded men, all of whom urgently require assistance, and many of them serious surgical operations, that it is impossible for them to do what they have to do as quickly as is desirable, however unceasing may be their exertions, much less to find time for deliberating on what ought to be done. Self-possession and decision without delay, grounded upon professional knowledge, are essential for the adequate performance of the onerous and responsible duties which devolve upon surgeons on the occurrence of such an event as a hostile engagement in the field on any large scale.

The situations where help is directed to be afforded to the wounded during the progress of an action and subsequently to it, and the arrangements ordered for ensuring that this help shall be systematically and speedily afforded, have been already sufficiently indicated in describing the system of surgical administration for general service in the field.

Administrative arrangements during siege operations.—In considering the circumstances of siege operations, whether with reference to the duties of the medical staff within a besieged town or fortress, or to those of the staff with the besieging force outside, the study of the means of preventing sickness again assumes the place of first importance. The higher the state of health that can be maintained among the troops, the more successful will be the results of the treatment of the wounded. Within the besieged place, these preventive measures chiefly consist in providing the necessary stores and varieties of food, and in economising their distribution, but particularly in the most strict and regular attention to sanitary regulations; among the besiegers, preventive measures must be chiefly directed to counteracting the injurious effects of the harassing duties, hard labour, miasmatic exhalations, loss of rest at night, and exposure to damp and chills, to which the troops are subjected in the trenches. To describe the best mode of accomplishing these desirable results is the province of works on military hygiene. The remarks which follow will be limited to points connected with the special administrative arrangements for the hospital service, and for the treatment of the wounded on occasions of sieges.

Arrangements inside a besieged place.—The provision of supplies for the hospitals should be specially considered. If the state of siege is likely to be of long duration, in addition to the usual hospital comforts, a stock of such articles as are likely to

prove serviceable in warding off scorbutic and allied conditions of body should be laid in freely. Sufficient stores of the remedies required for extensive burns, likely to result from explosions, or buildings set on fire by incendiary projectiles, should not be forgotten. If there is likely to be a want of water, the medical department should try and get a well sunk in the vicinity of the principal hospital while the men are strong and able; at the same time all means of collecting and storing rain water at the hospital should be carefully guarded.

In calculating the amount of medical and surgical stores which may be required under such circumstances, it is not enough to consider only the wants of the troops forming the garrison: the possible additional demands from a relieving force, should one get into the besieged place, must also be provided for. When the relieving forces of Generals Outram and Havelock made their way into Lucknow in September 1857, most of the regiments lost their medicines and surgical instruments during the advance through the hostile part of the city. They subsequently became almost wholly dependent on the stores of one regiment, the 32nd, for these important articles, and the stock of this regiment had become greatly reduced previously to the date named. The instruments were blunt and hardly fit to be used, the chloroform was expended, and the materials for dressing the wounded were exceedingly scanty. It should not be forgotten, also, when apportioning the medical staff to the troops in a place about to be besieged, that there will not be the means of replacing those who may fall sick, or who may die from disease or injury. An increase, proportional to the probable average number of casualties, should therefore be provided.

As soon as the siege has commenced, a regular roster of all the medical officers should be kept for garrison duty, so as to distribute the surgical labour as evenly as possible. Two medical officers should always be on duty together, for mutual aid, and in case of accident to either. A dressing-station should be fixed in some central position. Some of the inhabitants should be prepared for helping the men of the Medical Staff Corps and bearers in bringing the wounded to the dressing-stations.

When the storming of a breach is expected, the medical officers, with men of the Medical Staff Corps and bearers, should assemble in any suitable place near at hand, ready to give assistance. If the storming be successful, they must fall back upon the hospital. If the attack be repulsed, a truce will probably be agreed to, when some of the medical officers should get down to the ditch, to superintend the removal of the wounded from it and from the glacis. No time should be lost in removing the wounded from their wretched position about the ditch and its vicinity. Lanterns should be used, if necessary, for continuing

the search at night. The wounded of the besiegers who may be lying about the works should be given over to their own surgeons, to avoid encumbering the hospitals within the besieged place; if once brought inside, it is not likely that the commandant will allow them to return to their own force, lest they should give information injurious to the interests of the besieged.

Surgical arrangements with a besieging army.—When a besieging force is carrying on a regular siege—not merely investing the place with the intention of starving it into capitulation—the labours of the medical officers are always very severe and incessant. Notwithstanding that its communications are open, so that supplies of all kinds may be brought to the army, its sick and wounded quickly removed, and reinforcements brought up, the average amount of disease and mortality in a besieging force is usually greater than it is in the force besieged. This depends particularly on the unhygienic conditions to which besieging troops are usually exposed; and a most important part of the work of the medical department is to counteract the effects of this exposure as far as practicable.

The steps to be taken for the surgical care and treatment of the wounded will be much the same as those already described for an army engaged in action in the open field. Similar arrangements are required for giving primary attention to the patients in the trenches, for their removal from them, for the provisional treatment of their injuries, and for their conveyance to the field hospitals. As the field hospitals are, however, less likely to change their positions, it is only as they become encumbered with many occupants, or when they are ordered to be cleared in anticipation of a sudden increase in the number of wounded from an intended attack, that the same urgent necessity exists of evacuating them upon the hospitals in rear as is experienced in open warfare.

Some primary attention is usually given by a surgeon in as sheltered a part of the trenches as he can obtain, and the wounded men are then carried away under the shelter of the parapets on stretchers to dressing-stations if the field hospitals are far from the works. Some have expressed doubt whether the exposure of surgeons in the trenches is compensated by any good they can do to the wounded in such hazardous positions. Dr. Millingen, whose extended experience during the Peninsular sieges gave, at the time he wrote, great value to his opinions, stated that the surgeons were of little, or rather of no service in this dangerous situation;[16] and that it would be better for bearers to be stationed with their stretchers at such points of the parallels as the engineers might consider safest, and to carry off the wounded men without delay to the field hospitals for treatment. But there can be no doubt, from experience during the siege of Sebastopol,

that the surgeons in the trenches during that prolonged siege were of essential service to the wounded; and if shot-proof protection be constructed in an appropriate part of the works for the medical officers, as was then done, and should always be done when practicable, no less for the preservation of the surgeons than for that of the wounded to whom they have to attend, as well as to admit of a light being used at night, their presence must prove of great service. The surgeon's position should be as near to the most exposed troops as engineering convenience will admit, but not so near as to be liable to be surrounded in case of a sortie and of the enemy getting within the works. It should also be as central as possible, to facilitate the approach of the bearers from both sides of the trenches.

When the assault has been determined upon, a proportion of medical officers should follow the troops, but should not quit the most advanced parallel of the works while the attack is proceeding. There will be ample occupation for them in attending to the wounded who are able to make their way back from the open ground in front, without needlessly exposing themselves to the severe fire to which the assaulting columns will probably be subjected. But if the storming be successful, they should hasten forward to the breach, or the parts of the enemy's works which have been escaladed, as soon as the firing has ceased; for the numerous wounded lying there, probably heaped one upon another, will most urgently require assistance. They should be accompanied by as many bearers as can be got with stretchers, and every effort should be made to get the wounded removed as quickly as possible to places where they can obtain shelter and surgical attention. If the assault be unsuccessful, then, as before mentioned when referring to the arrangements with the troops besieged, it must be hoped that a truce will be mutually agreed upon for the removal of the wounded, as well as for the burial of the dead.

Administrative arrangements in case of an attempted invasion.—The general principles on which the wounded would have to be dealt with in case of an enemy making a successful descent on a part of the home country will be much the same as those already described for a general action. A considerable amount of uncertainty must exist as to the place on the coast where the enemy will try to secure a footing. Still, certain parts of the kingdom are more likely to be selected for such a purpose than others, and it is important that the means of carrying all necessary surgical assistance to the neighbourhood of those points where it might be expected an action would be fought should be well considered and arranged beforehand. The positions of the fixed and temporary hospitals relatively to any part of the coast where an enemy would probably attempt to effect a landing, and the

means of conveying the wounded to them, ought to be thoroughly determined. The organisation of the bearer companies ought to enable them to meet the first wants of the wounded, and also those connected with their removal by road or railway to the hospitals. The field hospital establishments should well answer the purposes of either primary or secondary hospitals in any places suitable for placing them. Specific instructions should be prepared, and kept ready for issue, on all points connected with these duties. The directions given on these heads should be marked with the greatest precision, for a misunderstanding might lead to clashing with other military arrangements, and even to disaster as regards the wounded. It is not to be forgotten that, in resisting an invasion, not only regular troops would be engaged, but militia forces and volunteers, who, while conferring great advantages in point of numerical assistance, cannot be expected to be familiar with many of the details and rules of military service. The interests of the wounded require that there should be equal precision in the administrative arrangements and orders of the medical department of the army as there usually is in those of the combatant branch for directing the movements of troops and of war matériel. The medical arrangements for the disposal of the men who are disabled can only be made with the approval of the combatant authorities, and in complete harmony with the general arrangements of the military service.

CHAPTER III

HOSPITAL EQUIPMENT

Preliminary remarks.—The equipment required for the care and treatment of the wounded in time of war consists of (*a*) the surgical, medical, ward, cooking, and table equipment—the whole being included under the general term 'hospital equipment;' and (*b*) the 'transport equipment'—this latter comprehending the store-transport vehicles and the sick-transport conveyances. The principal articles composing the different descriptions of hospital equipment in the British service, and the vehicles or other means by which they are conveyed, will be mentioned in the present chapter; the sick-transport equipment will be separately considered in the one succeeding. It is not intended to do more in this work than explain the general characters of the equipment; for the regulated methods by which medical officers are to obtain it when bodies of troops are preparing to take the field, and for particular details concerning many of the articles of the

equipment itself, the reader will be referred to the instructions in the official regulations on the subject.

The equipment of military hospitals varies materially in different armies. It may readily be understood that very different considerations will arise regarding the articles to be carried for field hospital use in a country whose forces may have to face hostilities in tropical as well as temperate regions, from those which will prevail in a Continental country whose troops are seldom required to act out of Europe. In all armies it is very important that the equipment, both hospital and transport, which is selected for being taken into the field, is suitable in kind, and such as can be relied upon for being at hand when wanted; for experience has shown that, when it fulfils all the purposes for which it is required, many surgical operations on the wounded may often be avoided, and the ratio of successful results will be increased when the nature or consequences of their wounds render such operations unavoidable.

The difficulties in the way of selecting the most appropriate equipment for field hospitals are very great and numerous. Almost every variety of casualty has to be provided for; yet military necessities, and the limitations of space, confine the selection of articles to such as are very simple in character, moderate in cost, and readily portable. They must be capable of withstanding rough usage. They must not suffer from being carried about from place to place, or be easily injured by exposure to changes of temperature and varieties of weather, especially in the British service. So many limitations and restrictions are practically met with in selecting hospital supplies for field use, that it becomes impossible to meet all the conflicting views that prevail among different surgeons on the subject, or to respond to all the demands that are made by them. The only practical plan is for definite scales of equipment, and fixed descriptions of articles, within the limits of weight and bulk allowed, to be laid down by the responsible authorities—such as experience has shown to be best suited for meeting the common needs of service—and for surgeons to conform to them; although it is known beforehand that in some instances, should special circumstances arise, articles might be chosen which would be better suited to meet the wants of these particular occasions.

Difficulties of a somewhat similar nature occur in determining the forms and construction of the conveyances for the wounded. It would be comparatively easy to design appropriate sick transport vehicles to meet any fixed conditions. But the conditions under which vehicles are required for the transport of wounded soldiers in the field are in no respects fixed. The conveyances must be made suitable for moving over almost every kind and condition of ground, whether made roads or rough fields; for all

kinds of weather; for use in winter as well as summer; they must be solid in construction, to resist the severe shocks to which they will inevitably be subjected in campaigning, yet they must not be too heavy; they must themselves admit of being packed in a small space for stowage on board ship, yet must be firm and secure when in use; and they must be fit for carrying patients in a sitting position and lying down, and suffering from every kind of injury to which men can be subjected. There must be conveyances suitable for use in mountainous countries, as well as for countries in which plains prevail. When a surgeon states the wants from his own point of view, he is met on one side by necessities from the combatant's point of view, and on the other by those which are bound up with the regulations of military constructors. Both of these are apt to interfere more or less with the execution of the surgical requirements. Thus, in the end, all that can be hoped for is the best pattern that can be obtained under a system of compromise: a conveyance so far adapted to the wants of the sick and wounded as the conflicting circumstances which it is designed to meet, and military requirements, will allow.

Seeing, therefore, that all the articles which constitute the equipment of field hospitals have to be special in character and design, it becomes most important that the officers and men who will have to employ them in time of war should become familiar with them in time of peace, accustomed to handle and use them, and acquainted with all the purposes they are designed to subserve. Without this familiarity, the equipment provided by the Government for an expedition is not likely to be properly understood in many of its details, and a want of knowledge of the proper use of one part of a contrivance will not unfrequently be the cause of the whole being thrown out of gear; some of the articles composing the equipment will not improbably be misapplied; and none of the equipment is likely to be so economically cared for, and maintained in order, as it ought to be.

Different classes of hospital equipment.—Supposing the different parts of the system for aiding the wounded in time of war to be organised on the principles which have been described in the previous chapters, the surgical equipment may conveniently be divided for consideration under the following heads: (1) the regimental equipment; (2) the bearer company equipment; (3) the field hospital equipment; (4) the stationary field hospital equipment; (5) the general hospital equipment; (6) the equipment of hospital ships; and (7) the equipment of the permanent hospitals.

The equipment of the first three divisions—the regimental, the bearer company, and field hospital establishments—is principally concerned with the treatment of gunshot injuries in the field, but it also includes the means of temporarily treating casual cases of

sickness. The equipment of the stationary field hospitals, and of the general hospital at the base of operations, has to be adapted to meet the requirements of men disabled by disease as well as of men disabled by wounds. This applies also to the equipment of hospital ships. The equipment of the permanent hospitals in the home country does not differ in war time from the equipment in time of peace. The articles of which it is composed and their numbers are to be found in the ordinary regulations of military hospitals.

Method of obtaining supplies of equipment.—It may be useful to mention the mode in which supplies are obtained on troops taking the field, before describing the supplies themselves.

At the time of the Crimean war, and up to the issue of the Revised Regulations for the Army Medical Department in 1859, the order was for each medical officer in charge of a body of troops, on the commencement of a campaign, to make a written requisition for the hospital stores, medical comforts, tents, and other equipment, which he supposed the sick and wounded of his corps would want in the field. When these requisitions had been approved and signed by the principal medical officer, they were forwarded to the apothecary's, purveyors', commissariat, or quartermaster-general's department, according to the nature of the articles required. The officers of these departments complied with them or not, according to their ability to supply the articles asked for or otherwise. This plan was attended with much inconvenience. It requires no little experience and discrimination to select supplies for the field with due regard, on the one hand, to the utility of the various articles asked for, and, on the other, to the means of transport, and to the circumstances of the country and operations in which the troops are about to be engaged. Another ill result of the plan was that, although the articles asked for were such as might tend materially to the welfare of the sick or wounded, occasionally some of them would not be supplied because the departmental officer, to whose discretion compliance with the requisitions was left, might take a different view from the medical officer in regard to their necessity.

A similar arrangement existed for obtaining the means of transporting the hospital stores and equipment. Requisitions had to be made upon the quartermaster-general's department, or on the military train, for any transport animals or carts which were required. Not only was delay caused by this system when the military train was encamped a long distance away, or when references to other authorities had to be instituted; but in all instances it depended upon the exigencies of other parts of the army in the field whether the necessary amount of hospital transport could be afforded. Thus, to use the language of the explanatory letter at the commencement of the Revised Code of

Regulations of 1859, 'In a case where humanity would suggest that the greatest prudence and forethought should be exercised in alleviating human suffering, the necessities of the sick and wounded are left subject to the ordinary accidents and contingencies of the field.'

The inconveniences experienced in the mode of supply just described led to the changes which were embodied in the Revised Code. In these regulations a defined scale of hospital equipment was appointed for every battalion, brigade, and division of an army, while a certain amount of horse and wheel transport was allotted for its conveyance in the same way as was done for stores to the artillery and other branches of the military service. In time of war, under all circumstances, the regulated proportions of equipment and transport were to accompany the forces to which they had been respectively allotted. In case of events causing an increase of the fixed establishment to be necessary, this addition was to be obtained, so far as the exigencies of the service would permit, by requisitions countersigned by superior authority. No countersignature was required for keeping up the regulation stock of equipment; to prevent delay, especially when a move was ordered, any deficiency in this stock arising from use was to be replaced on the requisition of the surgeon in immediate charge—a copy only of the requisition being transmitted to the principal medical officer. It was the duty of the senior purveying officer in the command to provide the medical comforts, hospital stores, and field equipment. The transport was to be supplied from the military train.

The hospital equipment ordered by the regulations abovementioned was carried in small portable cases called 'medical field-companions;' in larger cases called 'field-panniers;' while the bulkier articles of hospital equipment were carried in wheeled vehicles. It was ordered to be distributed in the following way: Each battalion was supplied with one medical field-companion, to be carried by an orderly; two field-panniers, forming a load for one mule; and one two-mule cart for hospital equipment. There was also a two-horse ambulance car, capable of carrying six or eight wounded men, for each battalion. In addition, each brigade of three regiments had a reserve store of equipment and medical comforts; and these were supplemented by a still larger divisional reserve store of the same nature. The object in view was that every division of an army should be prepared for subdivision into brigades or battalions, with their hospital equipments complete, and proportioned to the probable wants of the separate parts; while again, on the subdivisions being reunited, the means should exist for promptly supplying deficiencies which use or a sudden casualty might have caused in any part of the force.

The plan of laying down a fixed amount of hospital equipment for troops on taking the field was an immense improvement upon the uncertain method of each officer separately making a requisition for what he supposed to be needed. It placed, for the first time, the medical department of the army in the same position, in respect to equipment, as other branches of the military service. But modern strategy has led to the necessity for further improvements. It has elsewhere been shown that the system of each regiment taking with it a hospital establishment of its own into the field is an impracticable one in a modern campaign. Independently of the waste in a system which leads to an unnecessary multiplication of articles where a less number would suffice, it has become impossible for troops moving in the field as quickly as they now do to take such bulky stores with them. Whenever the plan was attempted, even in comparatively minor colonial wars, it was found necessary to abandon it.

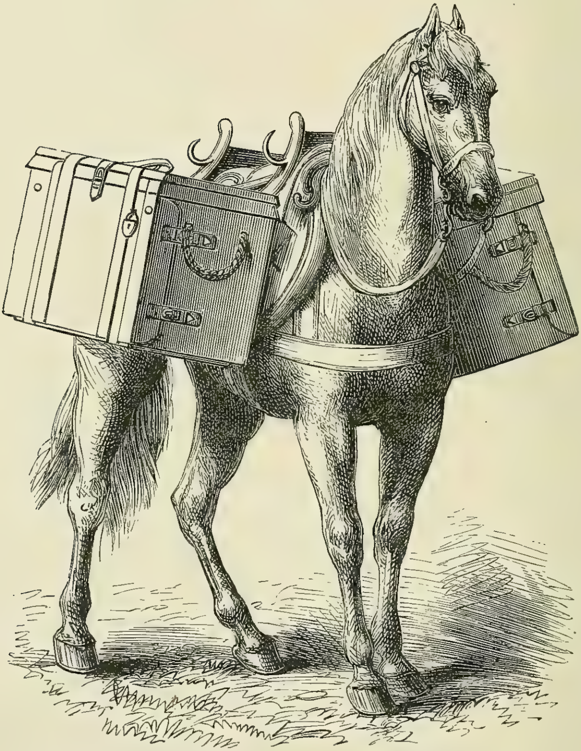
Articles composing field hospital equipment.—But though the manner in which the equipment was distributed has been for some time past discontinued, the articles composing it have not been all found equally faulty. Some of them are as good for their purposes as are to be found in the hospital establishments of any armies. The several kind of surgical establishments described in previous chapters—the field stations, dressing-stations, and field hospitals properly so called—require many of the articles of the service equipment that were in use under the system laid down in the Medical Regulations of 1859. The medical field-companions will be wanted for supplying temporary needs on the line of march, and at the first station of surgical help in case of action with an enemy. The field-panniers will continue to be the best form of equipment for meeting medical and surgical needs on the occurrence of various casualties for which the smaller medical field-companion is not designed; for use when detached bodies of troops halt for the night on the line of march; on the occasion of slight skirmishes; in mountain warfare; and under all circumstances when wheeled vehicles are inadmissible. The bearer company, under ordinary circumstances, will require waggons for the conveyance of bulky equipment, and ambulance waggons. Lastly, field hospital equipment vehicles with the same kinds of contents will still be required for the field hospitals, though the mule-carts ordered for the purpose by the Regulations of 1859 were proved to be faulty, and other kinds of conveyances have had to be substituted for them, and though these as well as all the transport animals have been placed in charge of the Army Service Corps, which has been since organised.

It is necessary for army surgeons to be acquainted with the nature of this equipment, the uses of the articles composing it, and the best means of keeping them in serviceable order in the

field, and a short description of them is accordingly now given.

Field medical panniers.—Of all the articles of equipment taken by surgeons into the field, the most generally useful hitherto have been found to be the medical panniers. They consist of wicker baskets covered with hide, and are each 2 ft. 4 in. in length, by 1 ft. 2 in. in breadth, and 1 ft. 6 in. in depth. They

FIG. 56.

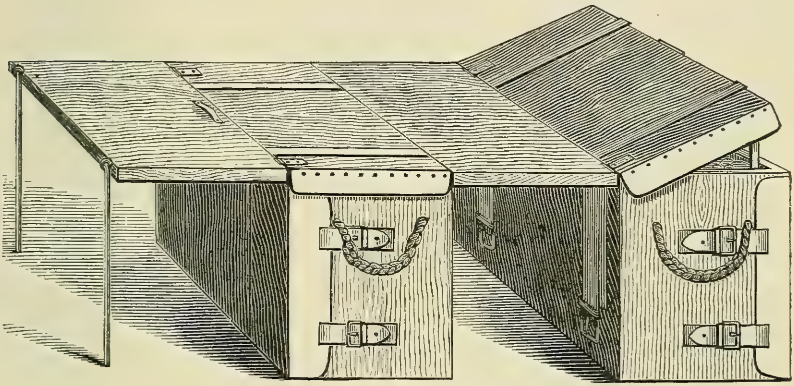


Manner in which Field Medical Panniers are carried.

are severally distinguished as No. 1 Medicine Pannier and No. 2 Material Pannier; the different names sufficiently indicating the general character of their respective contents. When about to be carried on a march, the two panniers are first fastened together by certain leathern straps which are permanently attached to them for the purpose. They are then secured to a pack-saddle upon a bat-horse or mule, in such a way that one pannier rests on

each side of the animal. The arrangements made for opening the panniers—the lids being capable of being raised upwards, while the fronts can be lowered downwards—enable all the contents of the two panniers to be readily got at without removing them from the animal that carries them. The handy size of these cases, the quantities and varieties of medicines and surgical materials which they carry, their comparative lightness combined with their toughness, the impunity with which they can be exposed in all climates and to all kinds of weather, are qualities which make them as suitable for receptacles of portable field stores as any, perhaps, that can be devised.[17] Wherever a soldier can go, there a mule with the field-panniers can follow, so that they need never be separated from the surgeon or from the neighbourhood of the wounded.

FIG. 57.



Panniers arranged to form a substitute for an Operating-table.

Their combined weight when filled is about 170 lbs., or a fair mule's load. Field-cases carried in a similar manner were used during the Peninsular war, but they only opened at the top, and chiefly consisted of unwieldy wooden chests bound with iron. They were very inferior in all respects to the field-panniers of the present time.

Improvements of late years in field-panniers.—An improvement, occasionally of great value on field service, was made in the medical panniers after the war in the Crimea. Arrangements were then made which enabled them to form a very fair substitute for an operating-table. This was accomplished by each pannier being furnished with a double lid, and with means of so joining the four lids together that a substantial support for a patient, nearly 5 ft. in length, could be formed by them. The plan for

forming the table is simple, and will be best understood by reference to the illustration (fig. 57). The advantages, as well to surgeons as to patients, of always having such means of support at hand on the field, in case of a necessity for the performance of amputations, are very considerable; for circumstances have often occurred to prevent the waggons carrying the regular operating-tables from being near the field of action when they have been wanted, and when no substitutes for them could be got. This happened after the battle of the Alma, and many amputations had to be performed while the wounded men were lying on the ground. Some minor improvements were also made at the same time, especially the introduction of a supply of medical comforts (only surgical materials and medicines having been carried in them previously); the use of patent bottles to prevent accidents from poisonous drugs; and a generally simpler and handier arrangement of all the contents. After the China war of 1860 an improvement was made in the position of the surgical instruments in the panniers. It was found that from being placed at the bottom of the pannier they were liable to become wetted in fording rivers; a fresh arrangement of the contents was therefore made by which they were placed on a fitting support at the top. After the Franco-German war of 1870–71 sundry other improvements were introduced. Among the more important of these has been the introduction of an irrigator for cleansing wounds, of hypodermic syringes and prepared solutions for use with them, metal wound-washing dishes, carbolised dressings, triangular bandages, wicker dressing-trays with the usual dressings ready for use, and a book and tallies for specification of wounds. These alterations were made without increasing either the bulk or weight of the panniers.

Contents of field-panniers.—The following is the official list of contents of the panniers of latest pattern :—

Contents of No. 1 Medicine Pannier.

MEDICINES.

In Body of Pannier.

Acid. boric.	oz.	2
,, carbolic, cryst.	,,	4
,, ,, liquid	,,	4
,, gallic.	,,	1
,, sulph. dil.	,,	4
Ammon. carbon.	,,	2
Antim. tartaratum	,,	1
Argent. nitrat.	,,	1
Chloral. hydrat.	,,	2
Chloroform pur. (in 2 bottles)	,,	9
Cupri sulph.	,,	1
Ext. opii liq.	,,	4
Inject. morphinæ conc.	,,	1
Ipecac. pulv.	,,	2
Iodoform	,,	$2\frac{1}{2}$
Jalapin	oz.	1
Liq. epispasticus	,,	1
,, ferri perchlor. fort.	,,	6
,, plumbi subacet.	,,	4
Mist. pro diarrhœa	,,	4
Morphinæ acet.	,,	$\frac{1}{2}$
Ol. menthæ. pip.	,,	1
Ol. olivæ	,,	4
Ol. ricini	,,	8
Ol. terebinth	,,	4
Pills, No. 7	doz.	9
Hydrarg. subchlor.		
Opii pulv., aa. gr. i.		
in each pill.		
Pills, No. 8	,,	5
Plumbi acet., gr. iij.		
Opii pulv., gr. i.		
Calumbæ pulv., gr. i.		
in each pill.		

MEDICINES (*continued*).

Pills, No. 9	doz.	5
Hydrarg. subchlor. Pil. rhei. comp. Pil. coloc. comp., aa. gr. ij. in each pill.		
Pills, No. 10	,,	6
Quininæ sulph. gr. ij. in each pill.		
Pills, No. 11	,,	2
Camphoræ, gr. iij. Opii pulv., gr. ij. Capsici pulv., gr. ½ in each pill.		
Pills, No. 12	,,	25
Opii pulv., gr. i. in each pill.		
Pills, No. 13	,,	5
Pulv. aloes Barb., gr. iss. ,, jalapæ, gr. ij. ,, colocynth, gr. i. ,, cambogi, gr. ¼ Sapo dur., gr. ½ Ol. carui, m. ¼ in 2 pills.		
Quininæ sulph. (compressed)	oz.	16
Spirit. ætheris	,,	4
Spirit. ammon. aromat.	,,	4
Tinct. aconiti	,,	1
,, chlorof. et morph.	,,	2
,, opii	,,	4
,, ipecac. et opii (liquid Dover's powder)	,,	2
Paraffinum molle (antiseptic)	lb.	1¼
Brandy	pt.	½
Water, distilled	,,	½
Zinci sulph.	oz.	2
Specification tallies, book, and pencil	No.	1
Pill tile, graduated and drilled	,,	1

INSTRUMENTS, &c.

Drawer No. 1.

Camel-hair pencils	No.	6
Clinical thermometer	,,	1
Corkscrew, compound	,,	1
Envelopes, linen lined	,,	25
Indelible pencils	,,	4
Ink, solidified	pkt.	1
Inkstand	No.	1
Knives, pill and palate	,,	2
Labels	,,	100
Mustard leaves	tin	1
Needles, hare-lip	No.	12
,, acupressure	,,	6
,, packing	,,	2
Note-book, with metallic pencil	,,	1
Penholders	,,	2
Pens	box	1
Pins, safety	,,	1
Scissors	No.	1
Spare leads for pencils	box	1
Spoons, tea	No.	2
Stethoscope	,,	1
Syringe, hypodermic screw with stoppered bottle of solution	,,	1
Ditto, ditto, with 2 tubes of discs	,,	1
Writing-paper	quire	½

Drawer No. 2.

Gallipots, in sorts	No.	3
Horn cup, graduated	,,	1
Ipecac. compressed, 20 gr. each	doz.	6
Measures, graduated glass, 2 oz.	No.	1
,, ,, minim	,,	3
Mortar and pestle	,,	1
Packthread	ball	1
Potass bicarb., compressed, 10 gr. each	doz.	15
Scales and weights, grain	set	1
Sodii bicarb., compressed, 10 gr. each	doz.	15
Stopper loosener	No.	1
Test tubes	,,	3
,, paper	books	2

Drawer No. 3.

Medicated gelatine discs and lamels . . . . . tin 1

Lamels for internal use—1 sheet each.
Antim. tart.; emetia; ipecac. extract; iron ammon. citrate; James's powder; mercury chloride (calomel); morphia mur.; nucis vom. extract; opium extract; opium and ipecac.; podophyllin; quinine.

Discs for hypodermic solution—1 tube each.
Curara; eserine; ergotine; morphia; morphia and atropia; quinine; strychnine.

Discs for ophthalmic use—1 tube each.
Alum; atropine; atropine and morphia; calarbarised; copper sulphate; opium and lead acet.

Brass syringe, with rose jet, in waterproof bag	No.	1
Candles, wax	,,	4
Candle and match-boxes, complete	,,	2
I.R. enema, with tubing, stopcock, and rose-headed jet for irrigation	,,	1
Zinci chlor.	oz.	1

Lower Compartment.

Splints, Duncan's patent, in tin box (the longest pair is in No. 2 pannier)	set	1
Surgeon's instruments, in flax cover	case	1

In Lid of Pannier.

Gimlet	No.	1
Screwdriver	,,	1

Contents of No. 2 Material Pannier.

(All appliances are antiseptic.)

Basket A.[1]

Fast-edged bandages	No.	6
Calico bandages	,,	6
Leather cases, containing needles, thread, &c.	,,	2
Lint, antiseptic	oz.	8
Plaster isinglass (in 2 tins), inch-tape	yds.	12
Plaster adhesive, inch-tape, each 6 yards	tins	6
Sponges in 2 wrappers, German cloth, with straps	No.	12
Tourniquets, field	,,	4
,, screw	,,	2
,, Esmarch's web, elastic	,,	6
,, tape	,,	12

Basket B.

Triangular bandages	No.	12
Cotton-wool, antiseptic	lb.	1
Extract of meat (in 4 tins)	lbs.	2
Etna, improved, with 2 drinking cups, and tin of rectified spirit	No.	1
Kidney-shaped basins for washing wounds	,,	4
Urinal, enamelled iron	,,	1
Lantern, with glass and candle complete	,,	1

Wrapper.

Antiseptic gauze	yds.	6
,, silk protective	,,	2
Calico	,,	4
Waterproof dressing-cloth	,,	2
Waterproof sheeting (German cloth)	,,	$2\frac{3}{4}$

Tin C.

Tenax	lb.	1
Creosote, in stoppered bottle and boxwood case	oz.	2
Sulph.-chromic catgut, in stoppered bottle and boxwood case	hanks	6
Indiarubber plaster, adhesive	tin	1
Drainage tubing, assorted sizes, under false bottom	yds.	6
Lion forceps	pair	1

Tin D.

Calico bandages	No.	6
Fast-edged bandages	,,	12
Flannel ,,	,,	4

Strapped in the Lid.

Medical prescription book	No.	1
Long jointed splint, Liston's	,,	1
Splints, Duncan's	pairs	1
,, wire, with pad cases, straps and buckles	,,	2

The illustrations (figs. 58, 59) show the manner in which the contents are arranged in the two panniers.

Tallies for specification of injuries and treatment.—The necessity for a surgeon noting any special circumstances connected with a wound after it has been attended to by him, or precautions to be taken during transport of the patient, to prevent unnecessary future interference or additional injury, has been previously referred to. The book of tallies in No. 1 Pannier has been introduced for this purpose. The book serves merely to keep the counterfoils of the tallies together. The tally consists of a piece of strong linen material, prepared for being written on, $4\frac{1}{2}$ in. long by $2\frac{1}{2}$ in. broad. It is double at one end, where it is punched and slit ready for being affixed to a button of the man's uniform. The following headings are printed upon it:—

No. and Name ______________________
Rank and Regt. ______________________
Wound ______________________
Treatment ______________________
Signature of Surgeon ______________________

[1] The basket *A* is constructed, and the contents arranged, to form two dressing-trays when occasion requires, so that half of the articles above specified are for each dressing-tray.

The remarks on each tally are also to be entered on its counterfoil, so that a copy of them may be retained by the surgeon who made them.

Care of field-panniers.—It is so extremely important for the welfare of patients as well as for the surgeon's efficiency, when, as often has happened in the field, the contents of the field-panniers constitute the chief surgical and medical resources of the surgeon in charge of a body of troops, that the panniers should always be at hand, and in good order for use—on the line of march, and indeed in all the varied operations of field service—that a few hints are added for the purpose of helping to ensure these objects being accomplished.

Pannier-mule.—The mule or pony to be employed in carrying the panniers should be chosen not only for its strength, but also for good temper. Care should also be taken that the orderly told off for the duty of leading it is a man who is likely to be kind and attentive to his charge. Nothing can be more harassing for a surgeon on a line of march than to find the pannier-mule proving restive, and perhaps breaking away from the orderly with the panniers. An untrained or vicious pannier-mule is a constant source of trouble and anxiety.

Pack-saddle.—It should be carefully ascertained, before starting on a march, that the pack-saddle is complete and strong in every respect, and particularly that it sits easily upon the back of the mule. It is not always easy to get repairs done when once a march has commenced, and if the saddle galls the mule anywhere, however quiet the animal may be naturally, it will certainly give trouble so long as the load is upon it.

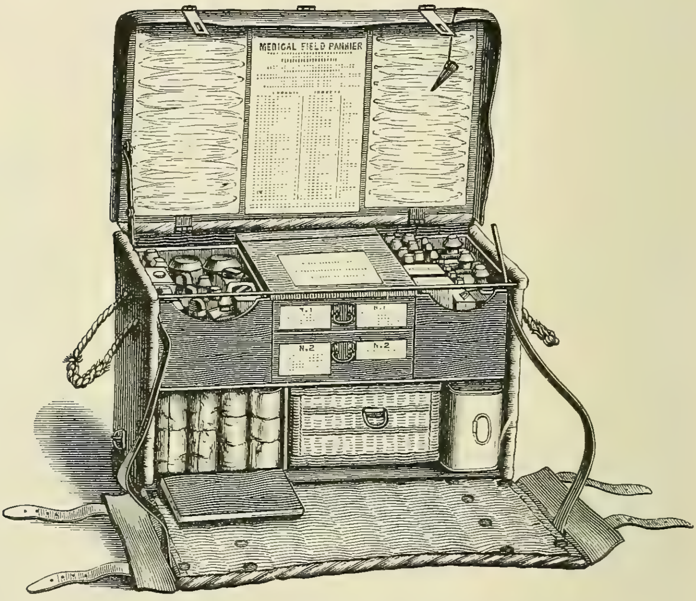
Weight of panniers to be evenly balanced.—The two panniers should be kept so weighted as to balance each other as nearly as possible. The burden to the mule is rendered easier by attention to this rule, and the object can always be accomplished with a little management. There is very little difference in the weights of the two panniers at starting—that of No. 1 Medicine Pannier being 90 lbs.; of No. 2 Material Pannier, 80 lbs.; and the weights are equalised on the line of march by the field medical companion being strapped on the lighter of the two panniers, as ordered in the medical regulations.

On no account should articles beyond those laid down by the official regulations be permitted to be placed upon the pannier-mule. Attempts will not unfrequently be made on a march to get the medical officer's consent for a cloak, or some such article, trifling in itself, to be carried on the top of the panniers. The only way to escape these importunities is to have a decided rule at starting that nothing is to be added to the regulated articles which the mule is appointed to carry. As before mentioned, the panniers and their contents weigh about 170 lbs., and this is an

average weight for the animal, having regard to its always keeping up with a column, and being at hand when wanted. The only occasion when any addition to this weight should be permitted is when military circumstances render it necessary to carry some rations of corn or forage for the animal's own use.

Distribution of contents of panniers.—The regulated arrangement of the articles contained in the panniers should not be changed. The contents cannot be better distributed than they are in the authorised method, which is clearly indicated by special

Fig. 58.



No. 1 Field-pannier open to show the general arrangement of the contents.

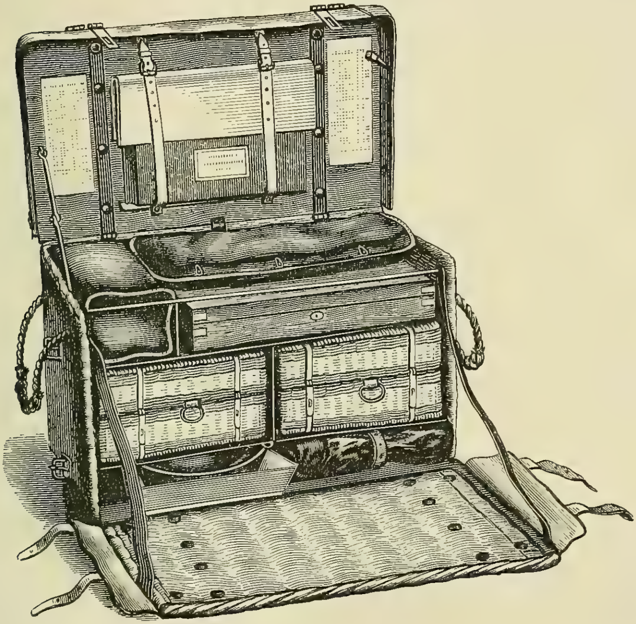
divisions within the panniers, and in the printed directions upon them. A fixed arrangement prevents waste of time when articles are required in a hurry. Moreover, it is easier to ascertain if any deficiencies exist, when the set distribution of the materials and medical comforts in their regulated compartments is not permitted to be disturbed.

Deficiencies in panniers.—The earliest opportunity should always be taken of replacing deficiencies in the field medical panniers from the stores in the reserve panniers. The contents of the field-panniers are to surgeons what ammunition is to com-

batants; and on active service the necessity for any one of the articles carried by them may arise at a moment's notice.

Surgical instruments.—The preservation of the surgeon's instruments which are carried in the No. 2 Pannier should have particular attention. This is essentially important under circumstances where if knives become much injured it may be impossible to get them repaired. It is a good plan in the field, after surgical instruments have been used and cleaned properly, to apply some oil or ointment to their surfaces, and afterwards to remove by

FIG. 59.



No. 2 Field-pannier open to show the general arrangement of the contents.

means of a dry cloth all the grease which is readily visible; the fine coating which will still remain acts as a protection against the damp vapours which rise from the ground in tents and are exceedingly penetrating. In well-protected buildings such applications to instruments are not only unnecessary, but are generally considered to be injurious. In campaigning, however well covered an instrument case may be, even though the covering may be waterproof, instruments are found to become rapidly rusty, and it is absolutely necessary to examine them at frequent intervals. A useful addition for a surgeon to make to the contents of the

panniers will be a hone and strap for sharpening the edges of his knives when they become blunted. It will not answer to depend upon a cutler, though one may be attached to the army; he may be a long distance off at the time his services are required. A strop is supplied with the 'special' surgical panniers, but these are not likely to be always near at hand when the strop is required.

Means of light.—Means of light are provided by a supply of wax candles and matches in the No. 1, and a candle lantern in the No. 2 Pannier. The want of light has been a source of great loss of time to surgeons in the field, and suffering to patients, in former campaigns, especially when surgical operations have been rendered necessary at night-time. Many operations that would otherwise have been done were stopped at nightfall after the battle of the Alma, owing to want of means of light. The candles are used in a convenient kind of lamp, furnished with a movable reflector, and made so as to be held in the hand or suspended by hooks, as occasion may require. The light can be concealed when necessary, without putting it out—often an important point in the field. The lamp is also arranged for heating a small metal vessel of water, with which to prepare some warm stimulant or beef-tea. Some brandy and tins of extract of meat are contained in the panniers.

Case of instruments carried in the surgeon's shoulder-belt.—All army medical officers under the rank of surgeon-colonel are required to be in possession of a regulation case of pocket instruments. When on field service this case is carried in the uniform shoulder-pouch, which is worn as part of their uniform. The surgeon's shoulder-belt answers a twofold purpose. In the first place, as an article of dress, it indicates the wearer to be an army medical officer. Combatant officers of infantry wear silk sashes over the shoulder; officers of the general staff, cavalry, engineers, Army Service Corps, and others, wear shoulder-belts of special colours or patterns, all distinct from one another and from those of medical officers. The latter may therefore be readily distinguished by this article of uniform. This is especially important on field service, when a surgeon should be capable of being recognised on the instant. Secondly, the shoulder-belt serves to carry the pouch which is made to contain the small case of surgical instruments before referred to. This arrangement ensures the constant presence with the surgeon of these appliances which are so essential to his professional usefulness. All executive officers who have a due regard to their own efficiency will take care to keep their instruments in a state ready for use; but it is one of the duties of surgeons of general rank to make sure that they are complete and in good order.

The following is a specification of the 'Surgeon's Case of Pocket Instruments' of regulation pattern:—

No.	Instruments and other Articles.	Dimensions.
		Inches.
1	Probe curved, and straight sharp-pointed, bistouries, in one handle	$3\frac{7}{8}$
1	Syme's abscess knife, and double-edge scalpel, in one handle	$3\frac{7}{8}$
1	Tenaculum and gum knife, in one handle	$3\frac{7}{8}$
1	Pair crooked scissors	$4\frac{3}{4}$
1	Spatula, German silver	$4\frac{3}{4}$
1	Bow dressing forceps, nickelled	$4\frac{3}{4}$
1	Director and aneurism needle, plated	$4\frac{3}{4}$
1	Pair artery forceps, fenestrated	$3\frac{3}{4}$
2	Probes, plated	$4\frac{3}{4}$
1	Male and female silver catheter combined	$4\frac{3}{4}$
1	Caustic-case with palladium crayon	$4\frac{3}{4}$
1	Clinical thermometer	4
1	Case for ditto, plated, with bayonet catch	$4\frac{1}{8}$
2	Bleeding lancets	$2\frac{1}{4}$
2	Dieffenbach's forceps, nickelled	2
1	Silver hypodermic syringe, in case with bayonet catch	3
6	Needles, plated }	$2\frac{1}{2} \times 2\frac{1}{8}$
1	Tablet of silk and wire for sutures }	
	All contained in a morocco single-flapped case with patent bolt lock	Length $5\frac{1}{4}$ Breadth $2\frac{5}{8}$ Thickness at clasp $1\frac{1}{4}$
	Total weight with instruments about $9\frac{1}{4}$ ozs.	

Surgeon's case of instruments.—This is now carried in the lower compartment of the No. 1 Medicine Pannier. The contents of this case are the following:—

	No.		No
Bistoury, straight sharp-pointed	1	Aneurism needle	1
,, curved ,,	1	Surgical needles with metallic thread	12
,, ,, button-pointed	1	,, for suture wire	12
,, for hernia	1	Half-curved needles for sutures	6
Double tracheotomy canula, silver	1	Amputating saw, single	1
Olivary catheters, Nos. 1, 3, 4, 7, 9, 12	6	Saw, with movable back	1
Silver catheters, Nos. 3, 5	2	Scalpels	3
Nickel catheter, No. 8	1	Tang scalpel	1
Steel hernia director	1	Common tenaculum	1
Double elevator	1	Screw tourniquet	1
Spencer Wells' forceps, nickelled, pairs	6	Trephine, medium	1
Fenestrated artery forceps, pair	1	Ferguson's thread, oz.	$\frac{1}{2}$
Bone forceps, pair	1	Extracting probang, double	1
Bullet forceps, pair	1	Reel of ligature silk	1
Dieffenbach's forceps, pair	1	Reel of plated wire for sutures	1
Dissecting forceps, large, pair	1	Long bullet probe, Nelaton's	1
Bladder trocar and canula	1	,, ,, silver	1
Liston's knives, 6, 9 and 11 in.	3	Extracting probang, double	1
Liston's needle, in handle	1	Sulphuro-chromic catgut ligatures, hanks	3

Reserve medical field-panniers.—These, as their name implies, contain reserves of medicines and materials for replenishing deficiencies as they occur in the medical field-panniers.

Their general arrangement is similar—No. 1 being the 'Reserve' Medicine Pannier; No. 2, the 'Reserve' Material Pannier. They are rather larger in their dimensions, chiefly in their width, but their combined weights are nearly the same as the united weight of the two medical field-panniers. Each field hospital has one pair of these panniers among its equipment, and from these the field medicine and material panniers, medical field-companions and surgical haversacks in charge of the medical officers of the bearer companies and of corps in the field are replenished as required, just as the reserve panniers of the field hospitals are replenished on requisition from the advanced depôt of medical stores.[18]

Special surgical panniers.—These panniers, which are arranged in pairs, distinguished as No. 1 and No. 2, contain various surgical materials, appliances, and instruments, that are usually only liable to be required on special occasions. They are not issued to medical officers attached to corps or bearer companies; but a pair of them forms part of the equipment of each field hospital, so that a surgeon can at any time obtain on requisition whatever particular appliance or instrument he may be in need of. The incumbrance of their conveyance by corps and bearer companies is thus avoided, and unnecessary multiplication of articles prevented, while the things themselves will be available for use whenever cases occur for the relief of which they are suited. The various articles contained in these special panniers are shown in the following lists:—

Contents of No. 1 '*Special*' *Surgical Pannier.*

Tin A.		
Anæsthetic ether	oz.	6
Carbolic acid	,,	8
Chromic ,,	,,	8
Chloroform, pure	lb.	1½
Iodoform	,,	1
Plaster, adhesive, 1-in. tape, 6 yds.	tins	6
,, ,, 6-in. tape, 6 ,,	,,	1
,, isinglass, 1-in. tape, 12 ,,	,,	2
,, soap cerate, 6-in. tape, 6 ,,	,,	1
Tin B.		
Aspirator	No.	1
Drainage tubing	yds.	12
Eye douche, with brass stem	No.	1
,, shades, assorted	,,	12
Ice bags, for the head	,,	2
,, for the spine	,,	1
Inhalers, 1 ether, 1 chloroform	,,	2
I.R. bottles, for washing wounds	,,	4
,, enema	,,	1
Tin C.		
Bandages, calico	No.	24
,, fast-edged	,,	24
Chamois skins	,,	2
Hypodermic syringes, with stoppered bottles of solution	,,	2
Leather case, containing needles, thread, tape, &c.	No.	1
Measuring tapes	,,	6
Scissors	,,	6
Stethoscopes	,,	2
Thermometers, bath	,,	2
,, clinical, in sliding cases	,,	4
Tourniquets, Esmarch's web	,,	24
,, field	,,	6
,, screw	,,	4
,, tape	,,	24
In Lower Division.		
Tin case containing catheters, sounds, &c., viz.:—		
Bougies, olivary, 1, 3, 4, 5, 6, and 8	No.	6
Catheters, olivary, 1, 3, 4, 5, 6, and 8	,,	6
Catheters, plated, 7 and 9	,,	2
,, silver, 3 and 4	,,	2
sounds, Lister's	,,	3
Gauze	yds.	12
Pus basins	set	1
Spongio piline	yd.	½
Tow	lbs.	2
Urinals	No.	2
Waterproof cloth	yds.	2¾
,, dressing-cloth	,,	4

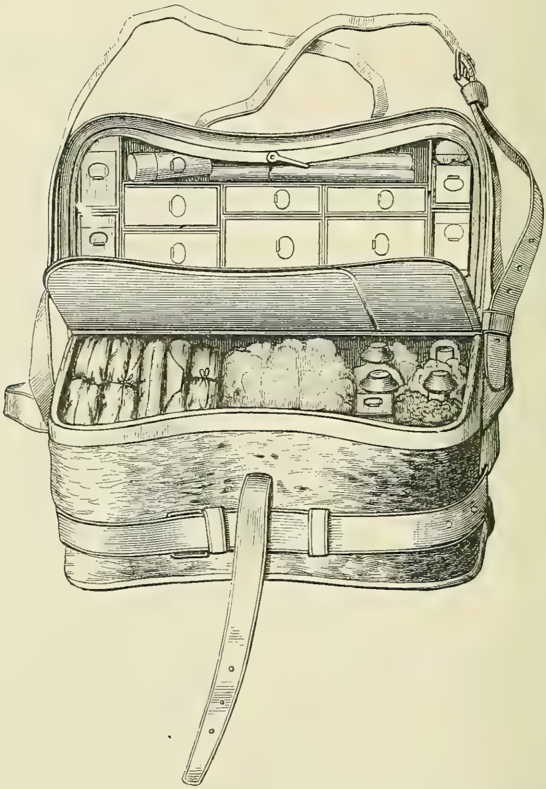
Contents of No. 2 'Special' Surgical Pannier.

Air cushions	No.	4
Calico, thin	yds.	12
Ether spray	No.	1
Eye baths	,,	3
Eye instruments	case	1
Instruments, operating (case 1), containing—		
6 amputating knives.		
6 bistouries.		
6 surgical needles, with metallic thread.		
1 set exploring trocars (4).		
1 necrosis forceps.		
1 tongue forceps.		
4 retractors.		
6 scalpels.		
1 reel plated suture wire.		
Mahogany case.		
Instruments, tooth (pouch 1), containing—		
4 pairs forceps.		
1 key.		
1 spring gum lancet.		
1 elevator.		
Lint	lbs.	2
Old linen sheets	No.	2
Razor and strop, of each	,,	1
Sponges, in 4 wrappers, with straps	,,	24
Stomach pump	,,	1
Arm sling, leather	,,	1
,, ,, wire, with pad	,,	1
Splints, viz.—		
1 double inclined plane, folding		
1 pair leg splints, left		
1 ,, ,, ,, right		
1 pair fore-arm splints	set	1
1 ,, upper ,, ,,		
1 ,, thigh splints		
1 radius splint		
with pad cases and covers		
Trusses, Cole's single	No.	4
Wool, boric	lb.	1

Field medical companion.—Infantry soldiers on active service usually carry a haversack made of canvas, with the upper part buttoning over. It is slung by a band across one shoulder, and forms a convenient receptacle for various articles not included in the field kits. It was the custom in former years for regimental hospital sergeants to use these haversacks for taking some lint and other materials for dressings on the line of march, with a small supply of medicines ready prepared for use, in order to avoid frequent recourse to the field-panniers. Some practical inconveniences resulted from employing them for this purpose, owing especially to the readiness with which glass articles carried in them became broken, and the difficulties in the way of keeping their contents dry in wet weather, as well as clean and in good order under ordinary conditions of service. After the Crimean war a substitute for the haversack was devised in the form of a substantial leathern case, arranged to be carried in a similar way by a strap passing over the shoulder. One of these cases was, for the first time, furnished to each regiment and corps engaged in the expedition against Canton in 1857, and was found to be exceedingly convenient for its intended purposes. It was divided into suitable compartments, each properly fitted; the contents were thoroughly protected from the effects of damp; the medicines selected were chiefly prepared in the forms of powders or pills, in doses ready for administration; the articles necessary for the first dressings of simple injuries were included; and there was a supply of cholera mixture, tincture of opium, and a few other essential remedies for urgent cases of sudden illness. A tin water-bottle and graduated horn cup also accompanied the case. This

useful appliance was called the 'Field Medical Companion.' Its weight is about 11 lbs. The present regulation pattern is very similar to the foregoing. It is carried, strapped to one of the field medical panniers when infantry are on the line of march.

Fig. 60.



Field Medical Companion.

With field artillery it is generally attached to the footboard of a gun limber.

The following are the contents of the field medical companion in present use :—

Contents of Field Medical Companion.

MEDICINES.

Chloroform	oz.	2
Iodoform	,,	1
[1] Mixture for diarrhœa	,,	1½
Spirit ammoniæ aromat.	,,	1½
Tinct. opii	,,	1½
Paraffin molle (antiseptic)	box	1

Pill and powder tin containing—

No. 1 . . . . . . doz. 1½
Emetic.
Antim. tart., gr. i.
Acacia pulv., gr. iij.
in each powder.

No. 2 . . . . . . ,, 2
Hydrarg. subchlor., gr. ij.
Pulv. jacobi, gr. iij.
,, ipecac. co., gr. x.
in each, compressed.

No. 3 . . . . . . ,, 1
Ipecac. pulv., gr. xx., compressed.

No. 4 . . . . . . ,, 2
Pulv. cretæ arom. c. opio, 20 grs. in each, compressed.

No. 5 . . . . . . ,, 2
Pulv. jalapæ comp., 20 grs. in each, compressed.

No. 6 . . . . . . ,, 4
Acid. gallic, gr. iijss.
Morph. mur., gr. ⅛.
Ext. gentian, gr. i.
in each pill.

No. 7 . . . . . . ,, 5
Hydrarg. subchlor., gr. i.
Pulv. opii, gr. i.
in each pill.

No. 8 4
Plumbi acet., gr. iij.
Pulv. opii, gr. i.
,, calumbæ, gr. i.
in each pill.

No. 9 . . . . . . ,, 4
Hydrarg. subchlor.
Pil. rhei co.
,, coloc. co. aa, gr. ij.
in each pill.

No. 10 . . . . . . ,, 8
Quininæ sulphatis, gr. ij.
in each pill.

No. 11 . . . . . . ,, 3
Camphor, gr. iij.
Pulv. opii, gr. ij.
,, capsici, gr. ½.
in each pill.

No. 12 . . . . . . ,, 12
Opii pulv., gr. i. in each pill.

No. 13 . . . . . . doz. 4
Pulv. aloes Barb., gr. iss.
,, jalapæ, gr. ij.
,, colocynth, gr. i.
,, cambogiæ, gr. ¼.
Saponis dur., gr. ½.
Ol. carui, m. ¼, ft. pil. ij.
2 pills for a dose.

TABLETS.

No. 14. Aromatic confection, ʒ ss. each, No. 16.
No. 15. Opiate confection, ℈ i. each No. 24.

SURGICAL APPLIANCES, &c.

Bandages, open woven, No. 3.
,, suspensory, No. 2.
,, triangular, No. 6.
Calico, thin, 1 yard.
Boric wool, 2 oz.
Candle and wax matches, in tin case.
Horn cup, graduated.
Lint, ¼ lb.
Measure minim, in case.
Plaster, adhesive, each 6 yards, 1-inch tape, 2 tins.
Plaster, isinglass, 12 yards, 1-inch tape, 1 tin.
Gutta-percha tissue, ¼ yard.
Catheters, olivary, 3, 6, 8, No. 3.
Sponges, surgeon's, No. 3; zinc basin, small; in waterproof bag.
Improved ratan splints, with pad cases, 1 pair.
Tourniquet, field, No. 1.
,, Esmarch's web, No. 2.
,, tape, No. 6.

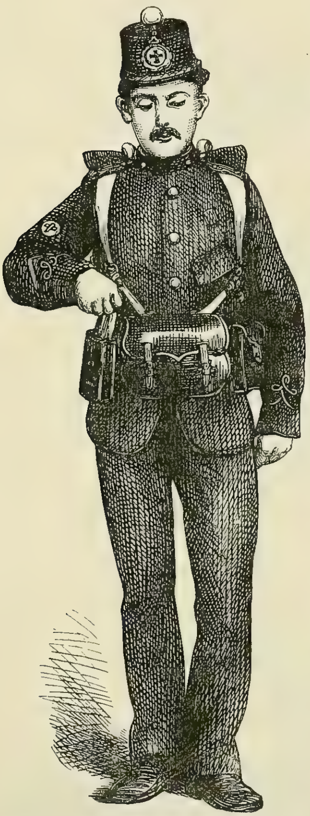
Leather case containing—
Ligature thread.
,, silk.
Surgeon's needles (6).
Sewing-needles (6).
Hare-lip or acupressure pins (6).
Safety pins (6).
Sulphuro-chromic catgut ligatures.
White wax.
Scissors.
Tape.
Pins (½ paper).
Hypodermic syringe, in case, with bottle of concentrated morphia injection and tube of morphia discs.
Water-bottle, with drinking-cup and strap complete.

Although no inconvenience was experienced by infantry soldiers in carrying the field medical companion in China, where they had their knapsacks carried for them, this cannot be done in Europe,

[1] Ol. anisi, ol. cajeput, ol. juniperi ā ā ʒ iss., liq. acidi halleri, tinct. cinnam. ā ā ʒ ij. M., 'Ten drops every quarter or half hour in a tablespoonful of water.'

where no such practice is followed. It is regarded in the British army as a military necessity that soldiers shall never be divided from their field necessaries, and this was especially enforced by the experience of the evils which resulted from the men being separated from them in the early part of the Crimean war. The question of the best mode of carrying the field companion was considered by the members of the committee at whose recommendation the knapsack was replaced by the present valise equipment, and experiments were instituted by them on the subject. As, on the one hand, it was laid down as essential that the valise equipment should be worn for the carriage of the soldier's field necessaries, and as, on the other, the sergeants or orderlies by whom the field medical companions would have to be carried were not required to carry ammunition (not being armed with rifles), a ready way suggested itself for the carriage of the contents of the field medical companion by utilising the ammunition pouches to hold the medicines, and by substituting for the ball bag a larger bag to carry the surgical materials. The necessary balance of the valise equipment on the waist-belt was thus maintained, the supplies were always at hand for distribution, while the weight to be carried would be no greater than that carried by every infantry soldier. Two medical pouches and a surgical bag were adapted to the valise equipment on the principles just named, and some sets of these were tried at the autumn manœuvres of 1872, and were favourably reported upon. The drawing (fig. 61) shows the manner in which they were carried. They were not, however, officially sanctioned.

Fig. 61.



Field Medical Companion adapted for carriage by hospital attendants wearing valise equipment.

In the French field medical service the regimental *infirmier* is equipped in a manner somewhat similar to that just described. He carries a *havresac* containing various dressing appliances, bandages, &c., together with two pouches, which resemble ammunition pouches, also containing articles for wound dressings.

The medicine pouches and bag of surgical materials so arranged could be equally well carried when the waist-belt alone was worn, and the contents could be got at without difficulty. When the valise and greatcoat are worn, the surgical bag can be carried in front, in the same way as the large ammunition pouch is carried by soldiers of the Belgian army, and as the 'tourist bag' has been worn by pedestrians with the valise equipment in accordance with the designs of the late Professor Parkes. When the valise was not worn, the bag could be shifted round the waist-belt, and carried behind in its place. The shifting was easily effected without unfastening the waist-belt, when the pouches and bag were passed over the end of the waist-belt to which the tongue was attached, and not from the opposite direction. The weight of the two medicine pouches and surgical bag, complete with their contents, was 6 lbs., or nearly half that of the regulation pattern; and, as the reduced weight was more widely distributed, it was on this account more easily borne than that of the original field medical companion. The diminution in the weight was obtained without lessening the efficiency of the contents. A few alterations in them were made, but the changes were not of much importance.

Surgical knapsacks.—It has been the custom for knapsacks fitted with surgical dressings and appliances to be carried in Continental armies with battalions of infantry. They have taken the place of the English field medical companions. In some armies the knapsacks are carried on the march by the surgical orderlies, special provision being made for the carriage of their own field kits; in others, the surgical knapsacks are carried in regimental medical carts, and are only put on by the orderlies when occasions arise for their employment. Obviously men cannot carry their own knapsacks and the surgical knapsacks at the same time. Field medical companions are also more convenient than surgical knapsacks, because their contents can be distributed by the wearers without removing them from their persons, which cannot be done with the knapsacks; while, if removed for any purpose, they can be more easily and rapidly put on again than knapsacks.

The 'first field dressing.'—The stores already described should always be forthcoming at the appointed stations; but during the Crimean war a plan was introduced in the British army for making sure that no soldier should be wounded and means for dressing and bandaging his wound not be at hand, in whatever part of the field he might fall. By an Army Medical Department circular, dated May the 27th, 1855, medical officers were informed that the Secretary of State for War had decided that a field-dressing should form a component part of every British soldier's kit on active service, so as to be available at all times and in all

places as a first dressing for wounds. The materials and form of the first field dressing were ordered to be as follows:—Bandage of fine calico, 4 yards long, 3 inches wide; fine lint, 12 inches long, 3 inches wide, folded flat and fastened by four pins. It was ordered to be carried in the soldier's knapsack. This plan for ensuring the presence of means for dressing wounds in the field has since been adopted in all civilised armies. On the occasion of the Ashanti war of 1873–74, the materials composing the first field dressing were altered in several particulars. The dressing included a packet of lint, on which a little simple ointment had been spread, enclosed in waxed paper; a triangular bandage; two safety pins, and a small packet of ordinary pins. The whole of these articles were folded into a small flat package $4'' \times 3\frac{1}{2}'' \times 1''$ in dimensions, which was covered by waxed paper. It was carried in a breast pocket, which was made of suitable size to contain it, in the lining of the left side of the tunic. This was a better place for keeping the first field dressing than the knapsack or valise. On some occasions in fighting, combatants are ordered to disencumber themselves of their valises, and some hours may elapse before they are again obtained. If placed in the valise, therefore, the field dressing might be absent on the very occasion for which it was contrived. It is now ordered to be carried within a sewn-up pocket on the inside of the skirt of the soldier's jacket when he goes on active service. It is thus secured against misapplication to other than its intended purpose, for a soldier would be liable to punishment if he removed it without due cause, and at the same time is readily got at either by the soldier himself or a neighbour when a proper cause occurs for its employment. It is not issued in common with other surgical dressings, as might be anticipated, but is supplied by the Army Clothing Department. Its composition, since July 1891, has been as follows:—Within an outer grey fine linen cover (fine holland) is a thin waterproof cambric inside cover, which is rendered air-tight by being cemented at the edges. Both covers can be readily opened when necessary. The inner cover contains two safety pins, a piece of waterproof cambric $12'' \times 6''$, and this encloses a gauze bandage $4\frac{1}{2}$ yards long folded flat into a package $4'' \times 2\frac{1}{2}''$, a piece of gauze $17'' \times 13''$ also folded flat, and about 160 grains of compressed flax charpie between layers of gauze. The charpie can be teased into a thick pad. All the dressing materials are rendered antiseptic by impregnation with perchloride of mercury, 1 in 1000. The weight of the complete dressing is 2 oz. The following directions are printed on a label pasted on the outer cover:—'Open the packet by tearing the black thread from the centre at the long stitch. Remove the outer envelope, tear open the second, and apply to the wound in the following order: 1st, the wool pad; 2nd, the square piece of gauze; 3rd, the waterproof. Fasten lightly with

the bandage and pins. If two wounds, put the pad on one, and the piece of gauze on the other, and divide the waterproof.'

Bearer's dressing-case.—The field medical companion, previously described, has only been designed for being carried by a sergeant or orderly in attendance on a surgeon. The medicines contained in it are such as should only be administered under the directions of a qualified practitioner. But all hospital attendants of the Medical Staff Corps require some suitable means for executing the minor operations connected with surgical patients which they are taught to practise. In removing foul dressings, and performing various acts of attention to wounds and sores, these men in former days habitually used their fingers. Occasionally this led to mischief to the patients, and also to their attendants. Sores were sometimes produced on the hands of the orderlies which were very difficult to heal.

FIG. 62.

Moffitt's Dressing-Pouch for trained bearer of wounded.

A hospital attendant's pocket case should only contain the instruments necessary to enable him to perform the minor surgical work which he is qualified to execute. To cut up a boot for removal from a wounded foot, to adapt and fasten a splint, to cut off a bandage on a director, to sew up linen coverings and bandages, to spread an ointment on lint, and such minor operations, are things which he has been taught to do, and which it is his legitimate duty to do as occasion requires. In the field, too, the application of temporary dressings to wounds—sometimes in the absence of a surgeon, and occasionally, when many wounded require aid, in the presence and under the direction of a surgeon—is work which he has been prepared for, and which it is often very important he should perform.

For the purpose of enabling hospital attendants to execute such duties properly, Surgeon Moffitt, for some time the Instructor of the Army Hospital Corps, designed a hospital attendant's pocket-

case and field dressing-pouch. The latter was only designed for time of war, and more particularly for use by bearers of wounded. The pocket-case was intended to be used in the wards of fixed hospitals as well as in the field. The instruments in the pocket-case and the materials in the dressing-pouch were very carefully selected. The pocket-case was to be carried in the man's jacket when on ordinary hospital duty, but in the dressing-pouch when in the field. The pouch was to be worn on the waist-belt, but suspended from the valise straps, as shown in the sketch (fig. 62).

Nearly all the purposes contemplated by Moffitt's field dressing-pouch and hospital orderly's pocket-case, which never received official sanction, are now fulfilled by the 'Surgical Haversack' and the 'Bearer's Dressing-Case.' These articles are included in the lists of regular field hospital equipment, and are issued to surgeons attached to all corps in the field, as well as to the bearer companies and field hospitals.

The **'Surgical Haversack'** is a waterproofed canvas bag, and contains the following surgical dressings and appliances:—

Bandages, loose-wove, antiseptic		4	Bearer's dressing-case		1
,, triangular		6	Lint, antiseptic	oz.	4
Boric wool	oz.	2	Sponges in waterproof bag		2
Plaster, adhesive, 1-in. tape, 6 yds., in tins		2	Wax candle and matches, in tin box		1
Plaster, isinglass, 1-in. tape, 12 yds. in tin		1	Wire arm splints, with tapes and buckles	pairs	2
Morphia injection, in stoppered bottle and case	oz.	½	Tourniquets, field		2
Sal volatile, in stoppered bottle and case	,,	2	,, screw, small		1
Cup, graduated, horn		1	,, Esmarch's web		2
			Specification tallies	book	1
			Pencil		1

The weight of the surgical haversack, with its contents complete, is about 5 lbs.

The **'Bearer's Dressing-Case,'** which is named above among the articles in the surgical haversack, is similar in shape to the surgeon's pocket-case of instruments, is made of leather, and contains the following articles:—

Clasp knife, long-bladed		1	Worsted	skein	1
Scissors, strong	pair	1	Needles, common		6
Forceps, dressing	,,	1	,, surgeon's, plated, in sizes		6
Spatula, platinum-plated		1	,, worsted		2
Probe and director, combined, platinum-plated		1	Pins, large		12
Sulphuro-chromic gut	skein	1	,, hare-lip		6
Thread	,,	1	,, safety		6

Surgical bag for cavalry regiments.—In addition to the surgical equipment with which medical officers attached to infantry battalions and regiments are supplied, surgeons attached to cavalry regiments are provided with a special case of surgical instruments for dealing with gunshot injuries and their effects. When detach-

ments of cavalry are at a distance away from the headquarters of their regiments on reconnoitring, skirmishing, or other duties, their movements are usually too rapid for any of the heavier articles of field equipment to be taken with them. Yet, in case of men being shot, important surgical proceedings may be necessary on the spot as a means of saving life. The cavalry surgical bag, which can be carried slung across the shoulder, has been designed to meet the necessities of such occasions. It is made of leather, is 10″ × 8″ × 4″ in dimensions, and is relatively light in weight, weighing about 4 lbs. The principal instruments in it are held as in a dressing-case, so that any may be taken out for use without disarranging others. The following is a list of the instruments and materials carried in the surgical bag :—

Contents of Surgical Bag for Cavalry.

Amputating saw	1	Blunt hook	
Amputating knives	2	Aneurism needle	1
Scalpels	2	Tenaculum	1
Finger-knife	1	Field tourniquet	1
Short bone nippers	pair 1	Nickel catheter, No. 8	1
Necrosis forceps	,, 1	Bullet probe	1
Artery ,,	,, 1	Acupressure pins	6
Torsion ,,	,, 1	Bandages	3
Dressing ,, (with catch)	,, 1	Needles.	
Bullet ,,	,, 1	Silver sutures.	
Bull-dog ,,	,, 3	Silk and thread ligatures.	
Scissors	,, 1	Adhesive plaster.	
Elevator	1	Lint.	

Boxes of apparatus for fractures and dislocations.—There are two boxes of such apparatus employed for army hospital use—one of a larger description, weighing nearly 100 lbs.; and one of a smaller pattern, weighing about 50 lbs. The larger box, stored at the headquarters of districts, is issued to hospitals when required for use, and is also supplied to troop-ships. The smaller box is the only one issued for use in the field, and is known as the 'Field Fracture Box.' The appliances and materials carried in it are as follows :—

Contents of Field Fracture Box.

Jointed thigh splints, wood	2	Plaster of Paris, in $\frac{1}{2}$ lb. tins	lb. 1
Wire leg splints, right and left	set 1	Antiseptic cotton-wool	,, $\frac{1}{2}$
Wooden ,, ,,	,, 1	Carbolised tow	,, $\frac{1}{2}$
Potts' splints, wood	,, $\frac{1}{2}$	Flannel serge, antiseptic	yds. 2
,, wire	,, 1	Gutta-percha tissue	,, 2
Pasteboard splints	6	Loose-wove bandages	12
Wire radius splint	1	Esmarch's bandages, printed	12
Counter-extension apparatus	1	Straps with buckles	12
Double-inclined plane, wire	1	Old linen sheet	1
Gypsum bandage instruments	set 1	Canvas covers to contain splints	12

Waggons and carts for the bearer company.—The waggons, two in number, are allotted, one for the carriage of equip-

ment, the other for medical stores. The medicines, surgical instruments, materials, and appliances are contained in wicker baskets, boxes, and cases of various descriptions, and carried in one waggon; while in the other are carried, also in panniers and cases of different kinds, various articles of equipment, with miscellaneous stores and supplies. The tents are carried in one of the two carts, while in the other the utensils and appliances for cooking purposes are carried, with miscellaneous supplies, reserve rations, and other stores. It is important that the officers and men of the Medical Staff Corps be well practised in the regulated distribution and packing of the stores in their respective conveyances. Lists of the articles to be carried are given in Appendix No. 56 of the Medical Regulations for 1890; but it has been announced that fresh arrangements are in progress, and will appear in a new special manual, entitled 'Distribution of Stores for a Bearer Company.'

The field surgical equipment which has been hitherto described, has been designed to meet the wants of wounded soldiers on the occasion of a general action, from the place where they receive their wounds, until they reach a field hospital, where the arrangements comprise the means of more complete surgical care and treatment. Each soldier carries on his own person a dressing for one or two wounds. The medical field companion and surgical haversack supply the means of further dressing, and also contain appliances and remedies which may be needed at the first line of surgical assistance, or at the station where the wounded soldier is transferred to a wheeled conveyance. Each surgeon carries a pocket-case of surgical instruments for minor operations. The field-panniers and the equipment of the bearer company supply the means of performing major surgical operations, by night as well as by day, that cannot be deferred with safety until the wounded men reach a field hospital, and also of administering various stimulants and restoratives. All the wants that may be expected to occur between the actual place of conflict and the field hospitals are thus provided for by these parts of the field hospital equipment.

Field hospital stores and transport.—It does not admit of dispute that the surgical and hospital equipment provided for the sick and wounded are, as they are often declared to be, an encumbrance to the fighting parts of an army, both from their bulk and weight, as well as from the requirements of the transport animals and their drivers. But it should be remembered that the sick and wounded are doubly so: on the one hand, they weaken an army by lessening its numbers in their own persons; on the other, by abstracting healthy men to attend upon them. The unfavourable moral influence which the presence of a body of disabled men always exerts, especially when their necessities are more or less disregarded, should also not be forgotten. Therefore the disadvantages attending the transport of the means

necessary for diminishing the accumulation of sick and wounded near the scene of action, for ministering to their necessities, and hastening their restoration to efficiency, must be balanced against the advantages arising from the employment of those means. But beyond this, the troops have a right to the best precautions which can be taken for their protection as well as for the safety of their lives, should they become endangered by wounds or sickness received in the service of their country. This is a right which has always been conceded by the greatest commanders, as well of ancient as of modern times. As Sir James M'Grigor has remarked, 'It is not only in the sense of humanity, but in that of a sound policy and real economy, that the state should provide able medical and surgical advice for the soldier when sick or wounded. I look upon it to be an implied part of the compact of citizens with the state, that whoever enters the service of his country as a soldier to fight its battles, should be provided with the same quality of medical aid, when sick or wounded, which he enjoyed when a citizen. In every large town, whence the great bulk of recruits is drawn, there are public hospitals and dispensaries, which, supported by the subscriptions of the rich, are always open to the sick and poor, and to persons of the middle classes; in fact, to those ranks in life from which the soldier comes. The physicians and surgeons of these public institutions are always the ablest men in the profession of medicine.'[19] The arguments which are here put forth for employing surgeons of knowledge and ability, necessarily apply to providing and placing at their disposal the means which are required to enable them to apply their talents to the benefit of their patients. At the same time it should always be borne in mind that the supplies for the hospitals accompanying troops ought never to be increased one fraction beyond what is absolutely necessary for efficiency. It is an important object to reduce the transport, as far as practicable, when an army is moving near an enemy. From this consideration, that arrangement will answer best which comprehends just sufficient equipment to meet the early wants which the field establishments are calculated to provide for, and, at the same time, that combines with it a reliable system for enabling fresh supplies to be brought from the rear, as occasion may require, to replace deficiencies in the front.

In considering this subject, especially with reference to European warfare, it is not to be forgotten that great changes have occurred in recent years with regard to the facilities for rapid and easy communication between places far apart from one another all over the Continent. In many districts and provinces which comparatively few years ago, had they become a seat of war, would have been encumbered by large collections of wounded men crowded in temporary hospitals, or in villages adjoining the place of conflict,

owing to difficulties in removing detachments of them to established hospitals at a distance off, there are now railways, good roads, and facilities of easy locomotion, which would obviate the necessity of all accumulations of the kind. Thus the call for carrying large quantities of surgical stores with the troops has become less urgent. A proportion of the wounded after a few days' interval can be conveyed to places where the required surgical stores and appliances already exist in abundance, and this can be done with hygienic advantage to the patients who stay behind, from not being in a fit condition for a long journey, by freeing them from the risks attending crowding, and at the same time, as a general rule, with considerable benefit to those who have been able to bear removal.

The equipment provided should be calculated for the probable percentage of wounded that may require assistance in case of a general action. This calculation can only be based on the results of the experience gained in the wars of recent years. The probable influence of any alterations that may have been since made in the weapons with which the troops are armed must be taken into account. Having established an approximate number, the nature of the casualties which may be expected to occur, and the relative proportions of the different kinds of casualties, have next to be considered. The statistics of former wars, so far as observations on these points have been recorded, must also be relied upon for help in obtaining this information. Regard should next be had to the probable number of days the wounded may be expected to remain in the field hospitals; and when a conclusion on this point has been arrived at, the kinds and numbers of the articles of equipment to be provided may be fairly determined. One or two repetitions of similar engagements with the enemy should be provided for. These are the only reasonable principles on which hospital equipment can be estimated for, with due regard to economy, and a fair assurance that the demands which will be made on the hospital establishments will be able to be met. Reliable surgical histories of wars, and the statistics derived from them, are thus most important subjects for study by administrative medical officers. Some statistics that may perhaps be turned to account in framing the proportions of equipment required for field hospitals will be found in the section on ratios of casualties in war.

The hospital stores which have been already enumerated—those for the field and dressing stations—have been particularly arranged for use in places and under circumstances where the transport vehicles, containing the bulkier stores of the field hospitals, cannot be expected to be available. The field hospital transport, however, can move with the army in all places where other heavy store transport can go. The field hospital stores are of great importance for the welfare of the wounded, and it is essential that

they should never be beyond easy reach in case of an engagement happening with the enemy.

As it has been laid down that a movable establishment for 100 sick and wounded men is to constitute a field hospital unit, it may be useful to indicate the kind of equipment taken with it, and the way in which it is carried. Circumstances may render it necessary for the troops to move without cover of any sort, as the Germans generally did during the Franco-German war; while on some occasions cover may be provided. Again, under other circumstances, not only cover, but even a proportion of bedsteads, which all surgeons know to be very advantageous for the treatment of some severe wounds, may perhaps be capable of being carried for use. It is better, therefore, not to lay down a single scale of equipment for field hospitals, but to prepare scales of supply to suit the various conditions of campaigning under which the troops may be placed. Thus separate scales may be drawn out for the field hospital equipment when tents are not to be carried, and when they can be carried; others according to the nature of the country in which the operations are to take place—in a country consisting chiefly of plains, or in one that is mountainous, and so on. Scales of equipment are laid down on these principles in the regulations on this subject. On an expedition being undertaken, it would devolve on the officer in command to say on which scale the field hospitals are to be furnished. In the composition of a field hospital, shown at page 540, the transport named includes the amount required when tents are carried.

By the Regulations of 1893, the equipment of a field hospital for 100 patients when wheeled transport is employed, is to be carried in seven general service waggons and two carts. There are also two water-carts. The medical and surgical equipment occupies four of the general service waggons, each drawn by four horses; the baggage and reserve rations fill two others; and one waggon is appropriated to A.S.C. details. The two transport-carts are for supplies and tents; the whole, with the two water-carts included, requiring thirty-six draught horses and eighteen drivers. If, instead of wheeled transport, pack-transport is ordered, then eighty-three mules with twenty-eight drivers are allotted to each field hospital. If cart-transport is held to be more suitable than waggon-transport for a particular campaign, then sixteen carts are allotted to a field hospital, and eight of these are appropriated to the surgical and medical stores.

The various articles of surgical, medical, and pharmaceutical equipments which are conveyed in the waggons are packed in canteens, wicker baskets, or closed panniers. The last-named include the field medical and surgical panniers and special surgical panniers. In the same manner are carried all the ward stores and utensils of first necessity for use in a field hospital, whether established

under canvas, in detached buildings, or in a village. The stores carried include supplies of medical comforts, such as essence of beef, arrowroot, tea, sugar, rice, wine, brandy, and others; the different sorts of cooking and table utensils; the bedding, and essential ward appliances. The stores are intended to provide for all the wants of the wounded who may be admitted into the hospital, in respect to accommodation, nursing appliances, warmth, cooking, and dieting; as well as to furnish the stewards and attendants with the means of carrying on their administrative and executive duties. Hours may elapse before the ordinary rations, which in the field are issued alike to the patients in hospital and to the healthy, can be supplied and prepared for their use. In the meantime the field hospital equipment and supplies will enable the wounded to have all necessary requirements in respect to support and sustenance, as well as surgical attention, very fairly provided for.

The equipment for the 100 patients of the field hospital is distributed among the four waggons. It is so arranged that two of the waggons have together a complete assortment of the equipment for 50 patients, so as to provide for the case of the field hospital being divided into two half field hospitals.

The supplies allotted to a field hospital are so varied in kind, and the miscellaneous articles so numerous, that to enumerate them all in detail would occupy a very considerable space, and be of doubtful advantage in the present work. Lists of them will be found tabulated in the Equipment Regulations for Service Abroad, and in the 'Manual on the Distribution of Stores for a Field Hospital.'

Field hospital pharmacy waggons.—These waggons were constructed in accordance with the report and designs of a War Office Committee, known as the Field Hospital Equipment Committee, and were built specially to contain all the surgical instruments, materials, appliances, dressings, and medicines for the use of a field hospital, and also to carry a small supply of stimulants, medical comforts, and some cooking utensils, supplementary to the supplies of the same nature in the equipment waggons. The pharmacy waggon has been so arranged that not only any description of article carried in it may be readily got at without interfering with, or displacing other articles; but also, to admit of medicines being compounded at it by means of a hinged dispensing platform and other conveniences at the rear of the waggon, without the necessity of carrying the bottles or cases in which they are contained away from the waggon. This is an important provision, in order to facilitate the work of the dispensers; to prevent articles from being taken away from the waggon and mislaid; and also to economise time when the waggon itself has to be closed up and moved, which it ought always to be

possible to do at a minute's notice. Each article has a special place assigned to it in one or other of the compartments of the waggon; and each compartment has a printed list of its contents attached to it. As the pharmacy waggons were intended to be not only the medical and surgical supply waggons for the field hospitals with the troops, but also to be interchangeable with those which are used in the hospitals along the lines of communication and at the base, it was necessary that the medicines and dispensing apparatus, as well as the surgical articles contained in them, should be sufficiently varied and ample to meet the wants of all these establishments.

The details of the construction of these waggons, together with drawings of them and measurements, as well as lists of the stores and medicines fitted to them, will be found in the Summary of Proceedings appended to the printed report of the Field Hospital Committee.[20] As present views are more in favour of such stores as those of the pharmacy waggon being packed in separate small panniers and cases, and carried in general service waggons, it seems hardly probable that these special pharmacy waggons will form part of the hospital equipment, even if circumstances should lead to a British force being sent on active service abroad.

Other field hospital waggons.—The general stores, such as the hospital tents, officers' baggage, and other bulky articles, do not require special construction of the vehicles by which they are conveyed. They can be as efficiently carried and protected in general service waggons and service carts as in any other conveyances.

Hospital tents.—Two kinds of tents have been used in British field hospitals—hospital marquees and bell tents. The marquee is by far the heaviest, its weight, when dry, being about 500 lbs. Its regulated accommodation is for eighteen patients; but when cots are supplied, not more than eight, or at most nine, sick can be placed in it with comfort; and, without cots, the number of sick ought not to exceed ten men whenever crowding can be avoided. Marquees never formed part of the regular equipment of field hospitals until after the recommendations of the Royal Commissioners who were appointed to inquire into the organisation of military hospitals after the conclusion of the Crimean war. The soldiers' bell tent, which is allotted to fifteen sound men on service, was generally supplied for the use of the sick in the field hospitals. It was made of single canvas, and was comparatively small in dimensions—the area of its base being 123 square feet, and the diameter 12½ feet, so that many practical inconveniences attended its employment for hospital purposes. They were thus summed up by the Royal Sanitary Commissioners: 'The bell tents are hot in summer, wet in autumn, cold in winter; unpleasant from their insecurity and waving movement in windy weather; too confined for the performance of professional duties; ill adapted for the

nursing of sick men; and far too limited on the floor to enable medical officers to render patients in any degree comfortable.'[21] And all these inconveniences became serious evils when the bell tents became old and threadbare from long service, as the old Peninsula tents were which were issued to the army in the Crimea during the winter of 1854-55. On the other hand, as supplementary to stationary hospitals, or for forming reserve hospitals, or when troops are posted in a standing camp, or halt for a few days when marching, marquees can be made very comfortable for patients. From being double, and from there being a space between the outer wall and the lining, they are, as described by the commissioners before mentioned, 'temperate in hot weather, dry when it rains, moderately comfortable during the prevalence of high winds, while they afford greater shelter than bell tents against cold, enable medical officers to approach the patients with more comfort to themselves, and permit the orderlies to attend better to the wants of the sick.' Hospital marquees were much improved in their construction some years ago, especially with respect to light and ventilation. By the present medical regulations for field service, tents are ordered to be carried as part of the equipment of field hospitals, but marquees are ordered to be stored at the base of operations, and issued for hospitals on the lines of communication when other shelter is not available. (Regulations, 1894, p. 80, par. 509.)

The bell tent has always been a useful part of hospital equipment, especially when it has been employed as an adjunct to the marquee, on account of its lighter weight, and the consequent facility with which it could be raised and packed up again. The modern circular tents are far superior to the old bell tents in form, height of walls, protection, interior space, and ventilation. There are two forms in use—the circular single tent and the double circular tent. The former, complete with its pole, weighs about 74 lbs. when dry; the latter, 100 lbs. Like all canvas tents, they increase about one-fourth in weight when wet. Four patients may be accommodated in one of these tents without much inconvenience.

Hospital servants require to be well trained in pitching and packing hospital tents of all kinds with celerity; their employment will frequently depend upon the ability of the men of the Medical Staff Corps in this respect. If they are not adepts in the work, but are awkward, and occupy a long time in pitching or striking them, surgeons will hesitate to use them on many occasions, lest the probable delay in getting them ready and packing them up again may interfere with the movements of the hospital, and do more general harm than good to the sick. The exercise of pitching and striking tents, as well as of raising, striking, and repacking hospital marquees, forms an important part of the

practical instruction given to the men of the Medical Staff Corps at the Training Depôt at Aldershot.

Tent for surgical operations.—A double circular tent, without lining, forms part of the equipment of a bearer company for use as an operating-tent. The field medical panniers are designed to act as an operating-table, as before mentioned, on ordinary occasions; but in a standing camp hospital, such as existed before Sebastopol, a circular bell tent may be easily turned into a very convenient operating-theatre, both as regards the patient, and also as to space for the surgeon, his assistants, and the attendants. For this purpose the central pole of the tent is removed, and, instead of it, three poles of about the same height are made to support the tent, their lower ends resting upon a ledge of ground just within the tent curtain. The whole floor of the tent is thus left free. This is now sunk by excavating it all round sufficiently for the surgeon and his assistants to stand well upright within the tent. A part of the earth is left untouched in the centre, of convenient size and shape, to serve as the operating-table, after being suitably covered by a blanket and waterproof sheet.

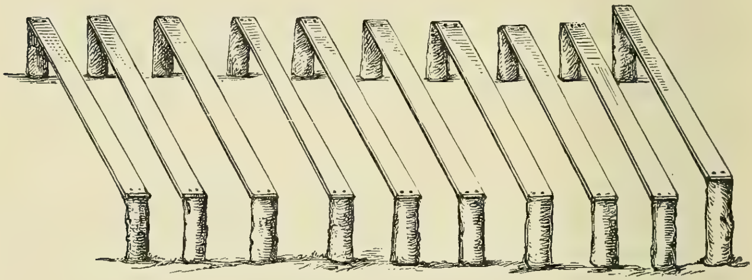
Field bedsteads.—Bedsteads are really very necessary articles for protecting patients from the deleterious influences to which they are exposed in campaigning when they are laid upon floors in farm out-buildings, or on the ground in tents. At the same time, as ordinarily constructed, they are too bulky and too heavy encumbrances to be included in the general equipment of field hospitals. Some impromptu substitutes for regular bedsteads have often to be employed, therefore, on occasions when military operations are prolonged.

In the old Army Medical Regulations [22] it was shown that temporary bedsteads may be constructed in the field for patients in a short space of time, and at a trifling expense. Some faggot-wood, drawn on requisition, with a few nails, are all that are required for the purpose. The sketch on the next page (fig. 63), of a field bedstead, and the following description of the mode of putting it together, are quoted from the regulations referred to above.

Temporary field bedstead.—'This temporary bedstead is formed by two rows of stakes driven into the ground, rising fourteen inches above the surface, and standing ten inches asunder. The width of the frame must be determined by the bedding, and the number of stakes by the necessary length. The cross rails are made of the same materials split asunder, with the flat side upwards, and the ends properly prepared for the nails; but it is to be observed that the head-rail which supports the bolster is to be placed on stakes six or eight inches higher than the others. Between this frame and the palliasse a suitable defence of a mat or mats of straw is to be interposed.'

When wounded men are laid upon straw palliasses, each palliasse should be kept from touching the floor or ground by means of hay or straw, or, better still, by straw mats placed underneath. The art of making straw mats is soon acquired by soldiers. The patient can then be shifted from his place, without much disturbance, lying on his palliasse, while the hay or straw underneath is aired and dried, or, if necessary, destroyed, and replaced by fresh straw or hay. The mattresses that are found in farm-houses and cottages usually consist of ticking containing densely packed and matted wool. Such articles ought never to be used as beds for

Fig. 63.



Temporary Field Bedstead.

wounded men. They absorb and hold moisture of all kinds with great facility, and soon become more or less fetid. They cannot be cleaned or dried without much trouble and expenditure of time. A straw pallet, on the other hand, can be shaken up and aired without difficulty; and if discharges find their way into it, the cover can be washed and disinfected, the straw burned, and another supply obtained.

Concluding remarks on field hospital equipment.—However liberal the hospital equipment may be at the starting of an expedition, it is well to bear in mind that, in spite of all precautions, the casualties of war will sometimes deprive the troops of some of the articles composing it. Army medical officers should therefore be prepared to take advantage of any means which can be made to serve as substitutes for them. One of the traits of character which particularly made Baron Larrey so highly esteemed by that great judge of character, and quick observer of special usefulness in particular spheres of duty, the first Napoleon, was his remarkable fertility of resource in promoting the interests of his wounded patients. Larrey has recorded regarding the first great encounter in the Russian campaign of 1812, the battle of Smolensko—where the French admitted they had 1200 killed and 6000 wounded among themselves, and described the number of

killed and wounded left by the Russians to be incalculable—that the French surgeons found themselves destitute of all means of dressing their patients. They therefore, under Larrey's direction, made use of the paper found in the Government Record Office, which was occupied as a hospital, instead of lint. For charpie they substituted tow and the cotton of the common white birch. Paper even was spread as bedding for the patients to lie upon, for no straw or other suitable materials were to be obtained; all the furniture of the city had been pillaged and carried away, or was destroyed by the fire which consumed a great number of the houses.[23] At another time, in Syria, when there was a want of butcher's meat to make broth for the wounded, Larrey, with the approval of the general commanding the division, sacrificed a number of camels for the purpose. When this resource failed, he used horse-flesh. As a substitute for salt, gunpowder was employed, the nitre in it taking the place of the ordinary salt. The great Robert Jackson, whose writings are most worthy of perusal by all army medical officers, was made a prisoner during the American War of Independence, when he was serving in the 71st Regiment. He at once occupied himself in aiding the wounded, and no materials for dressings being at hand, he took off his shirt and tore it up into bandages.[24] Swords, bayonets, fire-arms, bits of branches from a tree, strips of uniform taken from the dead, pocket-handkerchiefs, and other such extempore means, have often been turned to account in place of regular splints and bandages, and, when judiciously applied, have supported broken limbs during the conveyance of wounded men from a field of action almost as efficiently as the best apparatus specially designed for the purpose. It is vain to expect to obtain in the field all the numerous appliances and instruments which are to be met with in a civil hospital in the midst of a civilised community. Yet some would appear to expect to find them there on all occasions and under all circumstances. It is stated in a report written by an eminent French surgeon of the surgical operations performed after the great battle of Solferino during the Italian campaign of 1859, that the insignificant number of resections of joints was not to be attributed to a voluntary abandonment of the operation, but that it was owing to the fact that the resection instruments did not reach headquarters until a week after the event.[25] But every surgical instrument case will surely contain a scalpel and a narrow saw, and, with these instruments alone, any resection ought to be undertaken rather than unnecessarily sacrifice a limb by amputation. The mind of the military surgeon should be trained to making himself familiar with such expedients. In this way, whenever professional difficulties of the kind above indicated arise, a good field surgeon will be ready to prove his superiority by exhibiting aptitude in turning to account every available resource

for overcoming them; while, under the same circumstances, a less energetic and competent medical officer will be paralysed on finding himself without the particular aids and appliances to which he has been accustomed in the fully provided hospitals of peace time.

CHAPTER IV

SICK-TRANSPORT EQUIPMENT

Preliminary observations.—I propose, in this chapter, to confine my remarks principally to a description of the conveyances which are at present authorised for use in the British service. I have discussed, in a work on the 'Transport of Sick and Wounded Troops,' most of the general questions connected with the removal of patients from place to place in time of war; and in this work I described the most important kinds of ambulance vehicles which at the time of its publication (1869) were in use in the armies of different countries. Since that date increased attention has been given to the subject, and many changes and improvements have been made in sick-transport conveyances in almost all civilised countries. An account of these changes will be found in a second edition of the above-named work, which has been revised and advanced to the year 1893, under the editorship of Surgeon-Captain W. A. Morris of the Army Medical Staff.

The different classes of ambulance conveyances have not been changed. They consist, as before, of (A) Stretchers; (B) Wheeled stretchers; (C) Mule litters and cacolets; (D) Ambulance waggons; and (E) Railway ambulance conveyances. No ambulance railway trains have been constructed in Britain like those which exist in the chief Continental countries of Europe, but certain methods of converting the ordinary railway waggons designed for the carriage of heavy goods into waggons suitable for the conveyance of wounded men are taught to the men of the Medical Staff Corps and practised by them. These methods will be noticed presently.

(A.) *Stretchers.*

General remarks on stretchers.—A stretcher is a sort of hand-litter consisting of two wooden side-poles, furnished with handles, and having between them a canvas support on which a patient can be carried in a recumbent position. This latter part —the bed—is maintained sufficiently firm by the stretching action of cross pieces of wood or iron, called the *traverses.* It is from the traverses, or stretchers, that the whole conveyance gets its

English name.[26] Stretchers in all armies are now generally furnished with foot-pieces, so that, when one is laid on the ground by the bearers, the patient lying on the canvas may not be subjected to the effects of damp, or to pressure from stones or other irregularities of the surface.

A combination of many qualities is necessary to constitute a good ambulance stretcher. It must be as light as practicable, so that it may be easily carried by the bearers with the additional weight of a man upon it; strong enough to resist shocks from rough usage; its poles and traverses must be sufficiently rigid, without undue bulk, to maintain adequate straightness, and to prevent the canvas from sagging when the patient is on it; it must be capable of being folded up, to economise space in stowage in vehicles and on board ship; it must have a firm but not hard support for the patient who is to be carried on it; and it must be economical in cost, on account of the large number required in the field. For an army of 60,000 men, it has been calculated that 2000 stretchers are wanted; being at the rate of 32 for each 1000 men, or 3 per cent., with a moderate margin for losses and breakages.

A wounded man may be carried on a stretcher by two bearers, but, if the distance be long, two other bearers are required to act as a relief during the transport, to assist the patient in case of need on the way, and to carry the arms, ammunition, and accoutrements of the wounded man to the rear. Stretcher-bearers require to be specially instructed in their duties. It makes all the difference between comparative ease on the one hand and aggravated suffering on the other, between almost complete escape from further injury and serious risk to life, whether wounded men—especially men with bones fractured by gunshot, and others with grave internal injuries—are placed and carried on stretchers by well-trained or untrained bearers. A suitably constructed stretcher, when carried by thoroughly trained bearers, forms the easiest and least objectionable conveyance for a wounded patient that can be devised; it enables him to be removed in a recumbent posture, and is free from the distressing jolts which are inseparable from transport in wheeled vehicles drawn either by horses or steam.

Time occupied in carrying patients on stretchers.—Some trials were made at Netley to determine the time occupied by trained bearers in removing wounded men on stretchers. It was found, when three bearers were employed, that to remove the accoutrements from a soldier while lying on the ground, to place him on the stretcher, to carry him, his rifle, and accoutrements, a measured mile over moderately rough but still level fields, and to lift him off again, occupied 26 minutes. Each of the three men thus employed acted in turn as a relief to the two men carrying the stretcher. They halted and changed eight times in the course of the mile. The time occupied in returning with the

empty stretcher was 18 minutes. Thus the total time occupied by the three bearers in carrying a patient a mile, and returning, was 44 minutes. Had it been necessary for the bearers to attend to a wound in the first instance, in addition to removing accoutrements and releasing the clothes of the patient, the time occupied in the transport and return would have probably been a full hour; and it hardly seems safe to depend upon bearers transporting a wounded man the distance of a mile, and returning to the place from which they started, in less than that time. If four bearers should be available, there would be some gain in time, but on an average the gain would not be much.

Stretcher of the Hospital Conveyance Committee.—An important improvement was effected in the field stretcher which was introduced for use in the British service in 1872 by the committee appointed by Sir John Pakington, then Secretary of State for War, to inquire into the general subject of hospital conveyances for the army. There had previously been two kinds of stretchers —one for carriage by hand, the other for special use in ambulance waggons. Thus, a wounded man, on being transferred to the waggon, would have to be lifted off the hand stretcher in order to be placed on the waggon stretcher. These were recommended to to be made alike, so that they might be interchangeable. The stretcher in the waggon could then be taken out and used as a field stretcher; and the field stretcher on which a wounded man had been carried could be lifted and put into the waggon in its place with the patient upon it. The painful disturbance to the wounded man of a change from one to the other was thus avoided. The plans submitted by the committee were sanctioned, but the advantage of the twofold use was gained at the expense of some additional weight in the stretcher.

The stretcher of the 1872 pattern consisted of a piece of stout tanned canvas 6 ft. long, by 1 ft. 11 in. wide, nailed with copper nails through an edging of leather to two ash side-poles, each measuring 7 ft. $9\frac{1}{2}$ in. in length. They were $1\frac{3}{4}$ in. square in the middle, but tapered slightly towards the handles. The lower edge of each side-pole was rectangular; the upper surface rounded. Two leathern collars were secured to each of them at the termination of the canvas; these were added in order to adapt the stretcher for insertion in the ambulance waggon. There were also two small leathern stops near the middle of each side-pole; they indicated the part at which the stretcher was to be placed on the wheeled support when used as a wheeled stretcher. The ends of the traverses were screwed to the two side-poles. They consisted of two flat steel bars, each 1 in. in width, $\frac{5}{16}$ths of an inch in thickness, and hinged in the middle. The hinge was secured by a steel binder slipping over it. The feet, four in number, were made of iron, single-hinged, and were enlarged at the lower end to prevent

them from sinking into the ground, from which they raised the stretcher six inches. The field stretcher of the British service previously in use had no feet to keep a patient off the ground. The weight of the stretcher complete was 25½ lbs. The whole contrivance was arranged so as to fold up readily for packing; and no part of it was separable, or liable, therefore, to be missing when the stretcher was required for use.

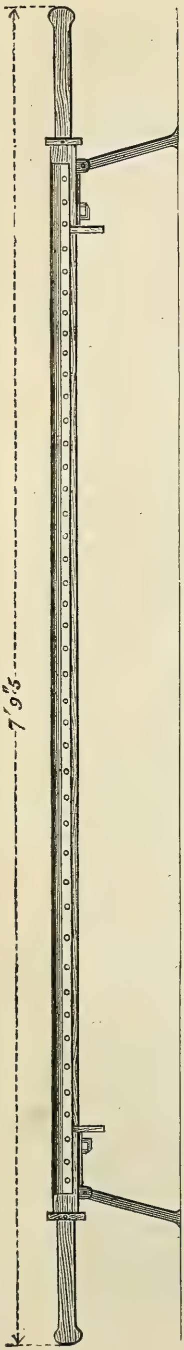
Each stretcher had eyelet holes to enable a pillow to be fastened to it by strings; but pillows were only intended to be used with the stretchers when employed in ambulance waggons, in each of which two pillows were kept for the purpose. In carrying a wounded man from the field, if it were necessary to raise his head on the stretcher, it could be done by placing the man's valise or greatcoat under his head.

The drawings, figs. 64 and 65, taken from the committee's report, exhibit a side view of the stretcher and a half plan of its two surfaces.

A change has since been made in the construction of the feet of this stretcher. Instead of the iron feet represented in fig. 64, the present regulation stretcher is fitted with four metal rackets carrying boxwood or lignum vitæ rollers, each 3 in. in diameter. These supports raise the stretcher nearly 6 in. from the ground. They have the inconvenience of not folding out of the way, as the feet did in the 1872 stretcher, so that the stretchers are rather more bulky when packed for hand-carriage or stowage; but the rollers are simpler than the folding legs, and enable stretchers to be moved in and out of the ambulance waggons with greater facility. This improvement was introduced by Surgeon-Major Faris. The weight has been increased 6½ lbs., the present pattern weighing 32 lbs. (see fig. 66). A diminution of the weight of field stretchers, without impairing their strength, is a very great desideratum. The French regulation army stretcher is considerably lighter, its weight being 10 kilos., or about 22 lbs. English. In connection with this alteration of the stretcher, a change was made in some of the fittings of the ambulance waggon, which will be noticed when the waggon is described.

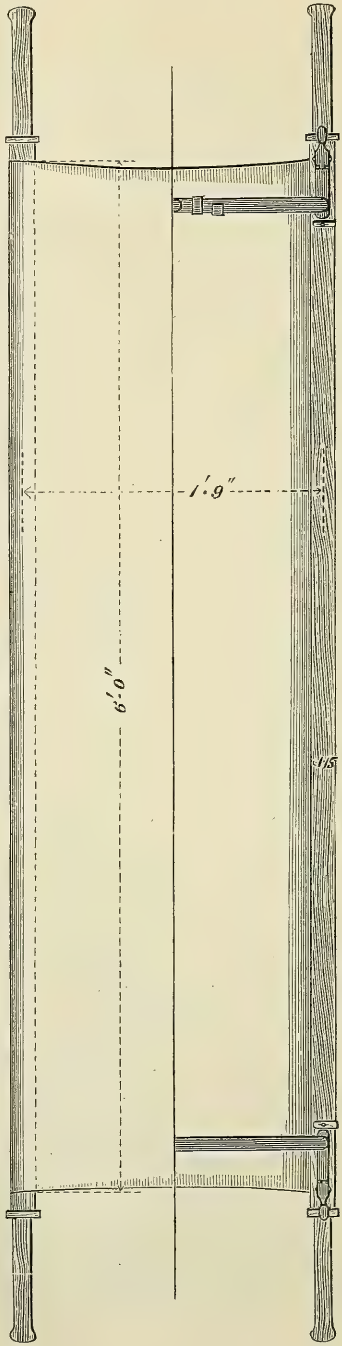
Shoulder-slings, that is, leathern straps, or bands of hempen webbing, made so as to rest across the shoulders of the bearers, and to terminate in loops into which the handles of the stretcher can be inserted, are of much use in helping bearers to carry stretchers. They enable the bearers to take off part of the strain upon the hands and arms, and occasionally to relieve them of it altogether. They thus add to the security of a patient while being carried on a stretcher. The end of a stretcher cannot be so readily dropped, in case of a bearer becoming weak or being careless, when it has the additional support of a shoulder-sling. The Hospital Conveyance Committee recommended that

Fig. 64.



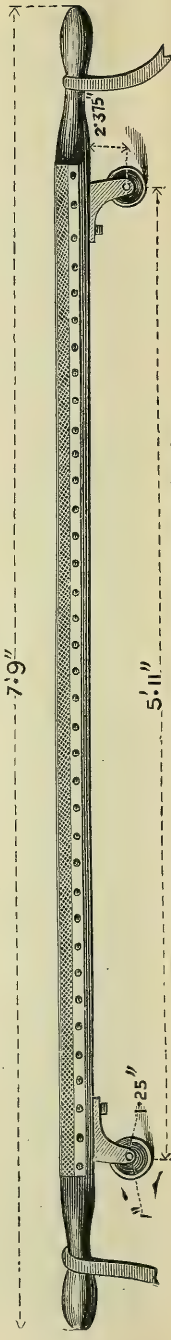
Side view of the Conveyance Committee's Stretcher, with measurements.

Fig. 65.



Half plan of upper and under surfaces of the Conveyance Committee's Stretcher, with measurements.

Fig. 66.



Stretcher of present Regulation Pattern, with roller feet.

shoulder-slings should form part of the equipment of all bearers. They were led to adopt this recommendation, as experience had shown that shoulder-slings are apt to be lost when issued with stretchers; and it was supposed that this would not be so likely to occur if the bearers were made responsible for them. The suggestion was not adopted, but a pair of leathern shoulder-slings, each 60 inches long and 2 inches wide, with a loop at one end, and a buckle fastening back on the sling at the other, so as to lengthen or shorten the sling as may be necessary, is now issued with every stretcher. These slings are fitted with small transverse straps 21 inches long, which serve the purpose of fastening the parts of the stretcher together when it is folded into a package.

Manner of removing patients by stretchers.—Some years ago I published a paper on the carriage of wounded men on stretchers in one of the volumes of 'Army Medical Reports.'[27] As the manner in which such hand-conveyances are used is of the utmost importance to the patients who have to be carried upon them, I insert here the principal observations which were contained in the paper referred to. They are equally applicable, and equally demand attention, when an injured person is carried on an improvised substitute for a regular stretcher; but the use of regulation stretchers by trained bearers is chiefly kept in view in the remarks.

The main objects to be aimed at in carrying these conveyances are, firstly, that as little as possible of the impulse connected with the progression of the bearers shall be communicated to the stretcher which they are bearing; and secondly, that the conveyance may be kept level, and as near the ground as freedom from risk of contact with things upon it will allow, and at the same time is consistent with easy carriage of it by the bearers. If one of these conveyances be badly carried, it may be shaken in such a way by the movements of the bearers as they step along, that the patient may be rolled upon it from one side to the other alternately. Again, it may have such a motion communicated to it that the patient may be jerked more or less *upwards* with every step; or the patient may be so placed that his head is lower than his feet, or in some way that is unsuited to the nature and site of his wound; or his body may be unevenly supported; in any of which cases the ill results of the movements just described will be felt with more severity. The conveyance, again, may be raised so high that the patient upon it may be kept in constant apprehension of falling off; or in case of one of the bearers accidentally stumbling and allowing the conveyance to fall, he may receive such additional injuries as to lead to serious, and perhaps fatal, consequences. All these objectionable movements and wrong positions, which would be irksome enough

to men in sound health, entail serious risks to men who are in mental and bodily distress, suffering, it may be, from fractures of bones, grave internal lesions, or other severe wounds. Fortunately such additional torture may be in a great degree prevented by observance of the points hereafter mentioned, whatever the circumstances of the ground over which the wounded man has to be carried may be, and notwithstanding that some differences may exist in the heights and strength of the bearers. All bearers ought to be physically powerful and active men, not only on account of the weight they have to carry, but especially on account of the circumstances under which they have to carry it when employed in field service.

One of the first things to impress upon bearers is that every movement of a man who has just been wounded must be made with extreme care and gentleness, to prevent not merely pain, but aggravation of his injuries. Care when raising him from the ground where he has fallen, when placing him upon the stretcher, when lifting the stretcher with the patient upon it, when halting and laying it down for the purpose of resting, when transferring him to another conveyance or to a bed—in each of these cases, careful though firm manipulation is as essentially necessary to obviate suffering and additional mischief as is a properly regulated step during the transport itself.

Very particular precautions are required when a patient has had a bone recently shattered by gunshot. The proper manner of accomplishing the delicate task of lifting and removing a man with such an injury, and the various modes of protecting the broken limb during the transport, are subjects in which all bearers of wounded require to be very specially instructed.

It has been hitherto usual, during active service in the field, for only two men to act with each stretcher, owing to a paucity of bearers. For several reasons, however, it is most desirable that three men, when a third can be spared, should accompany every stretcher which is employed in carrying a wounded man from a field of action. The third bearer is required in case of either of the other two bearers becoming wounded, to assist in placing upon the stretcher any man who has been rendered helpless by his wounds—especially one who has met with a serious fracture of bone from gunshot—and to act as a relief to one or other of the bearers who may become over-fatigued during the transport. A patient with a fractured thigh or leg should never be lifted up and put on a stretcher by two bearers only, unless under extreme urgency. The position of a patient after he is on a stretcher, too, both on starting and during the transport, frequently requires some rectification, owing to displacement from sagging of the canvas, or from the effects of movement during the carriage; and this can only be done, without

laying the stretcher down on the ground, when a third bearer is present.

Before the bearers, whether two or three in number, attempt to remove a badly wounded man from the spot where he has fallen, the stretcher should be brought as close to him as practicable; the wounded man should not be carried by hand farther than can be avoided. In placing the stretcher for this purpose, it *should not, as a general rule, be laid by the side of the patient,* but at his head; and should not be placed crosswise, but the length of the stretcher should be in the same direction as that in which the wounded man happens to be lying. If placed by his side, it interferes with the movements of the bearers in lifting him up, necessitates their moving to the end of the stretcher, or stepping across it, and is liable to cause them to stumble when they are depositing the patient upon it. If placed crosswise at the patient's feet, it leads to the necessity of the bearers turning round, and again causes the risk of one or other of them falling over the side-poles. These objections are avoided by the stretcher being placed longitudinally; the patient is readily carried head forward over the canvas on which he is to lie, and the bearers move with a clear view of the stretcher before and between them, until the patient's head is directly over the pillow or other support on which it is to rest.

The bearers told off for carrying stretchers in military service should be severally distinguished by some ready appellation. When two or more men have to act together in any concerted movement, one must take the lead; and so in the removal of wounded men on stretchers, one of the bearers, in the absence of a medical officer, must invariably take the direction of the duties connected with the transportation of the patient, if they are to be properly performed. The bearer who marches foremost may be designated the front, or No. 1, bearer; the one who is behind, the rear, or No. 2, bearer; and if a third bearer is told to assist in the transport, he will be the No. 3 bearer. The rear, or No. 2, bearer should assume the command, for his position enables him to see not only the patient on the stretcher, but the front bearer also; while the front bearer cannot see either, but only the objects before him. He is thus, however, enabled to see any impediments there may be in the way, and to give notice of them to the bearer in rear. It does not really matter practically whether the front or rear bearer takes the command; but what is essential is that it should be fully understood beforehand on which of the two bearers the direction and regulation of the movements devolve, so that there may be no hesitation when the necessity for action occurs. There are certain parts of the process which should always be conducted by a few short words of command; especially for lifting up a wounded man and lowering him on the stretcher, for raising the

stretcher, for the start, and for laying the stretcher down. The object is not so much to ensure the alert and sharp movement which is required in military exercises, as it is to ensure, without any loss of time, the necessary caution, steadiness, and well-concerted oneness of effort in the associated action of the bearers. It must never be forgotten that the alertness and precision with which the manœuvring of stretchers is performed by bearers at schools of instruction or parades are not the main objects in view; such manœuvres are only of importance so far as they are calculated to lead to shortening the time and degree of suffering, and to promoting the welfare of the patients who may afterwards have to be carried upon them. The systems on which bearers are drilled and exercised will vary to a certain extent in different armies; but so long as the ultimate purpose is steadily kept in view, and the means by which it can be effected in time of need satisfactorily acquired, it matters little what the system of instruction and stretcher drill may be.

Lifting up and placing a wounded man on a stretcher.—As soon as such essential attention as time and circumstances will allow has been paid to the general condition of the patient, or to the particular injury he has received—when the necessary prevention of movement of a limb, if a bone be broken, by any available support at hand; the arrangement of temporary supports on the stretcher itself, if needed for the injured part, by using articles of clothing or some of the man's accoutrements for the purpose; and any other matters which appear to be urgent have been attended to—the next thing is to place the wounded man on the stretcher.

With three bearers, this is best done by two of the bearers stooping down on opposite sides of the patient, near his haunch-bones, the two bearers facing each other. The third bearer places himself in a stooping position on the wounded side of the patient near his knees, ready to raise his lower limbs, and if a bone be fractured to give to it his undivided attention. The two bearers facing each other gradually get, each one hand, under the back of the patient, and then lock the two hands together; at the same time their other hands are passed and mutually grasped under the upper part of his thighs, as close to his breech as possible. The third bearer supports the lower extremities. As soon as this is done, the bearer who takes the direction gives the word 'ready.' At this word the bearers secure a firm grasp of the patient. The order 'lift up' follows. Immediately all the bearers, acting together, rise from the stooping posture, and, bringing their knees together, stand up. As soon as the erect position is gained, the order is given to 'march.' The bearers carry the patient head foremost until he is exactly over his place on the stretcher, and the order 'down' being then given, he is carefully lowered and deposited horizontally on the canvas.

With only two bearers present, one must sustain the weight of the patient's body, the other of the lower limbs. It will be easiest for the bearers to take up a position on opposite sides of the wounded man if the wound is not a very severe one in the thigh or leg; but if it be, and fracture exists, it will be better for both bearers to take their stand on the injured side—the broken limb can be better attended to and supported during the movement which is to follow. The successive steps of the movement itself, until the man is laid on the stretcher, are similar to those described when three bearers are available.

The start.—The start in every instance will be best accomplished by dividing the action into several parts, and assigning to each a brief but distinct word of command. As soon as the patient is settled upon the stretcher which is lying upon the ground, the directing bearer gives the word 'fall in.' At this command the two carrying bearers get into their proper positions between the side-poles at the head and foot of the stretcher, and the third bearer by the side of it. The bearer in command then gives the word 'ready.' The two stretcher-bearers at once stoop down, adjust the shoulder-straps, and take hold of the handles of the stretcher-poles. This being done, the word 'lift' is given, and immediately the two bearers rise and raise the stretcher carefully and steadily together. No sooner is the stretcher raised, and all is seen to be right, than the word 'march' is given, and the bearers at once move off.

Laying down a stretcher with a patient upon it.—In like manner, when the stretcher is to be lowered and placed on the ground, it will be best done by corresponding divisions of the action under similar short words of command. The directing bearer calls 'halt,' at which both stretcher-bearers stop, but without any abrupt or sudden jerk; the word 'ready' is then given, which is the signal for getting into position to stoop; the word 'down' follows, when the stretcher is lowered, and laid gently on the ground; and lastly, at the word 'fall out,' the two bearers quit their hold of the handles, and move away from the stretcher.

A systematic performance of these duties in the manner described is easily and quickly acquired, and when the bearers are sufficiently familiar with it, is not attended with any loss of time, is calculated to prevent many a mishap, and will lessen the pain to wounded or sick men on all occasions. Every bearer should be trained to take the position of a No. 1, 2, or 3 bearer; his services may be required on the moment in any one of them.

The men of the Medical Staff Corps are commonly drilled in marching with stretchers, and in loading and unloading them, with four bearers to each stretcher. The four bearers constitute what is called a 'stretcher squad,' and four such squads form a 'stretcher section.' The drill is carried out with precise gradation movements,

as in infantry drill, under many separate words of command; but presumably it is not anticipated that in the heat and tumult of action any such deliberate and methodical arrangements can be attempted in practice. Neither do I imagine, considering the probable relative numbers of wounded and bearers in the field, at least in European warfare, that at a time when it will be difficult to meet the urgent appeals of wounded men for speedy removal from the ground, as many as four bearers will be able to be spared for the carriage of each stretcher. In peace manœuvres, and on some special occasions in warfare, sufficient bearers may be present to allow of four being allotted to each stretcher; but, as a general rule, in an engagement of any importance, if a third bearer can be obtained to assist the two necessary stretcher-carriers in the removal of the wounded, it will, in my opinion, be a subject for much congratulation.

Some general rules on the carriage of stretchers follow:—

RULE 1. The front and rear bearers of the conveyance must start with opposite feet. They must not move 'in step,' but, on the contrary, must march out of step, or, as the ordinary expression is, must 'break step.' If the man in front step off left foot forward, the man in the rear must step off at the same moment right foot forward, and this broken step must be maintained throughout the whole distance of the transport.

It is not an easy matter at first to enforce this rule among men who have been used to march in the army ranks; indeed, it is only by systematic instruction and practice that the proper method of carrying a stretcher can be acquired by them. The art of marching in broken step is one of the most difficult lessons to be taught in the instruction of trained soldiers whose duty it may become to carry wounded men on stretchers.

The reason which dictates the rule for breaking step will be readily apparent on examination. If two men carrying a stretcher between them keep step in starting, as a front and rear rank soldier do in commencing to march, that is, if both men advance their left foot together, there must at the same time be a downward inclination of the body of each man towards the same side in proportion to the distance to which his foot is advanced, and equally so of the stretcher which they are carrying. When next the right feet are advanced together, the inclination will be changed from the left to the right side; and this alternate change of inclination will be unavoidably communicated to the man lying upon the canvas, and will be continued so long as the step is kept. The wounded man is placed in much the same circumstances, as regards the kind of movement to which he is subjected, as a man who is riding on a camel; instead of being, as he should be, in the position of one on the back of a horse when the animal is walking. But when the step is broken at

starting, that is, when the front rank man advances his left foot, and at the same time the rear man advances his right foot, as the horse does his opposite feet in walking, the dipping motion down to either side is avoided, and the surface of the stretcher can be maintained on a horizontal plane. With each step of the bearers there is a moderate upward and downward movement of the stretcher, chiefly owing to the pace of the men and to the elasticity of the side-poles; but, with this exception, the general level is preserved. There is no lateral movement, giving the patient a tendency to roll from side to side.

The rule equally applies if the stretcher be carried by four instead of by two men. The step must be broken by the front and rear rank men, so that the level of the stretcher may still be preserved.

RULE 2. The bearers must march with a steady but easy step, particularly avoiding all jerky movement or elevation of their bodies by springing from the fore part of the feet. The foot should be planted without any wavering on the ground at each step, and in moving forward it should only be raised sufficiently to clear the ordinary impediments on its surface. Some bearers, unless this rule is enforced, will make a slight spring at each advance, and this is of course communicated to the more or less pliable conveyance they are carrying. They do so under a conviction that the weight is sustained more easily in consequence of the elastic movement which is thus obtained, without taking note of its ill effect on the person who is being conveyed by them.

Length and kind of step best suited for bearers.—In carrying a stretcher, the pace should not be so long as it is in marching in the ranks, and the movement of the lower limbs should be conducted on different principles. When a combatant recruit is under instruction, he is taught, in practising the balance step, which forms the foundation on which the art of marching is built up, that the knee should be kept stiff, and the whole limb straight, when it is either advanced in front or extended behind. The movements of his lower extremities are all to be from his hips. The toe of his foot is to be advanced, and his foot brought to the ground at 30 inches distance, measured by the pace-stick, from heel to heel. This is the slow step; in stepping out, the pace is lengthened to 33 inches. In the ranks, not only is length of stride, and consequent speed of movement, gained by this proceeding, but it enables a uniform pace to be preserved with bodies of troops. At the same time, the length of the marching stride and the movement from the hips unavoidably induce a proportionate upward and downward movement of the parts of the soldier's body above the hips. The trunk sinks as the foot is advanced; it is raised as the limb is again brought vertically under it. This alternate elevation and depression is sufficiently

manifest to any one who observes troops advancing in line towards him, or, more conspicuously still, if they are moving on the other side of a hedge, with only the upper parts of their bodies exposed to view. The kind and length of pace just described will not answer so far as stretchers are concerned, if they are to be carried to the best advantage. The gait of the hawker who habitually carries a basket of crockery, or of a man carrying a bucket of water on his head, is the most suited to the circumstances of a patient carried on a stretcher; for, with such a gait, the trunks and arms of the bearers, and consequently that which they are carrying, are least lifted up or moved. The peculiarity of this gait is, that in it the hip-joints are used as little as possible, the advance is made with the knees kept slightly bent, and the step is shorter. The knees are never wholly straightened, as in marching. The length of the pace is about 20 inches.

The difference in the rise and fall of the upper part of the body between a pace of 30 inches and one of 20 inches is greater than might at first be suspected. When two men holding a stretcher without a man upon it make together a pace of 30 inches, measured from heel to heel, the dip of the stretcher is $3\frac{1}{2}$ inches; with a man upon it, the arms being then stretched to their full extent by the weight, the dip is $4\frac{1}{4}$ inches. When the pace is 20 inches, the dip, without a man upon the stretcher, is only $1\frac{1}{2}$ inch; with a man, $2\frac{1}{4}$, or about one-half of the dip in the longer pace. Of course in marching at either pace there is an alternate rise and fall to the same extent, and the effect of this on the elastic poles of a stretcher can readily be imagined. The amount of elevation and depression just mentioned is irrespective of jerking or any other movement, having been carefully measured when the bearers were standing still at each position.

There would be another difficulty if the ordinary marching step were used by men in carrying stretchers. The position of the traverse in most stretchers would cause it, with a pace of 30 inches, to press severely against the front and upper part of the advanced thigh of the rear bearer. The front traverse would also touch the back of the thigh of the front bearer; but as the general movement of this limb is away from the stretcher, the inconvenience would not be so much felt. Thus in trying to march with a pace of 30 inches, the rear bearer would be subjected to a sharp blow from the traverse on one or other of his thighs at every step. A jolt would also, at each contact, be communicated to the stretcher and patient upon it. With a pace of 20 inches, the traverse being placed at a distance of 13 inches, and the edge of the canvas at 11 inches, from the ends of the handles, the thigh of the rear bearer is well cleared from contact with both, and neither the traverse nor the canvas impede the bearers in their movements.

RULE 3. Care must be taken that the steps of the front and rear bearers are *even and alike in distance.* If the steps do not agree in length, there will constantly be a hasty 'catching up' of one or other of the bearers, and the stretcher and patient will be jolted on every occasion when an effort is thus made to readjust the distance. If the bearers march with an exactly corresponding step as regards length, this source of disturbance will be avoided.

RULE 4. When distributing bearers, as far as circumstances permit, men nearly of the same height should be selected for acting together. When a stretcher is supported by men of an equal standard, the stretcher will necessarily assume a horizontal position if the ground be level, and men possessed of somewhat similar degrees of strength will carry the weight and move together more evenly. If the ground be uneven, the bearers will have mutually to adapt the height of their respective ends of the conveyance to the irregularities, in order to preserve its level condition.

RULE 5. When slings or shoulder-straps are used to assist the bearers in carrying stretchers, care should be taken at starting that they are so buckled that the parts supporting the poles are all at equal distances from the *surface of the ground.*

RULE 6. As most ground over which wounded have to be carried is likely to present irregularities of surface, it becomes an important matter for bearers to practise the carriage of stretchers, so as to acquire a facility of keeping the stretcher level, notwithstanding the ground is uneven. Bearers of adequate strength, when trained and habituated to this duty, perform it with ease and dexterity, irrespective of differences, which cannot always be avoided, in their own respective heights; while those who have not practised it are not unlikely to cause considerable distress to the person carried when they have to carry him up and down inclined ground. A concerted action of the front and rear bearers is necessary, and each must be aware what part he is to perform, according as the end of the stretcher at which he is placed is rendered higher or lower by the unevenness of the surface over which the stretcher is being carried. The art can readily be acquired by practising the carriage of the litter up and down steps. In this practice the front and rear bearers should occasionally change their respective positions. A bearer should also be carried on the litter in turn, so as to be made practically aware in his own person of the effects of even and uneven carriage.

RULE 7. If the ground over which the conveyance has to pass presents a general ascent, and the bearers are of different heights, then the rear bearer should be the taller and stronger man; for his greater height and the greater strength of his arms will be useful in supporting and raising the stretcher up to the level of the end carried by the foremost man. The weight of the

stretcher will naturally be thrown in the direction of the man on the lower level.

Rule 8. If the ground presents a general descent, the front bearer should be the taller and stronger, for the same reasons as those just given in regard to the rear bearer under the opposite circumstances mentioned in Rule 7.

Rule 9. A sick or wounded person on a stretcher should be carried, if the ground be tolerably level, with his face looking towards the direction in which the bearers walk. The front bearer then supports the end of the stretcher at which the patient's feet are placed; the bearer near the patient's head is the rear bearer.

Rule 10. If the bearers have to carry the stretcher up-hill, the front bearer should support the end of the stretcher on which the patient's head is placed, excepting in the case mentioned under Rule 11.

Rule 11. If the bearers have to carry the stretcher down-hill, the rear bearer should support the end on which the patient's head is placed. The reverse position should be assumed by the bearers, both as regards going up-hill and going down-hill, in case the patient being carried is suffering from a fractured thigh or leg.

Under all ordinary circumstances, the level position of the stretcher, as before mentioned, should be sought for as much as possible; still, if the slope of the ground be such that it cannot be attained, it appears desirable that the inclination downwards should usually be towards the feet rather than towards the head of the patient. But with regard to the exceptional case named, the reversed position of the patient is advised, in order to prevent the risk of his body pushing the upper end of the broken bone down upon the lower portion at the seat of fracture.

Rule 12. A wounded patient on a stretcher borne by two bearers should never be carried over a fence or wall if it can possibly be avoided; it is always a dangerous proceeding. The danger is of course increased in proportion to the height of the wall or fence; but even if the wall be not much higher than what the bearers can manage to cross, the stretcher must be made to rest upon it, to the inconvenience and probable pain of the patient, while each bearer in succession gets over the obstruction; and it is better to avoid even this inconvenience, provided the avoidance does not entail great delay. If the wall or fence be rather high, either a portion of the wall should be thrown down, or a breach made in the fence, so that the patient may be carried through on the stretcher; or, if this be not readily practicable, the patient should be carried to a place where a gate or opening does already exist, notwithstanding the distance to be traversed may be increased by the proceeding. It is better that the transportation

should be somewhat delayed, than the safety of the patient risked.

RULE 13. In crossing a ditch, dike, or hollow, the stretcher should be first laid on the ground near its edge. The first bearer then descends. The stretcher, with the patient upon it, is afterwards advanced, the first bearer in the ditch supporting the front of the stretcher while its other end rests on the edge of the ground above. While it is thus supported, the second bearer descends. The two bearers now lift the stretcher to the opposite side, and the fore part being now made to rest on the edge of the ground, while the rear part is supported by the second bearer in the ditch, the first bearer is left free to climb up. The stretcher is now pushed or lifted forward on the ground above, and rests there, while the second bearer climbs up. The two bearers then carry on the stretcher.

RULE 14. If several loaded stretchers carried by two bearers are moving together, or if a stretcher is being borne by four bearers, other methods of executing the movements referred to under Rules 12 and 13 can be advantageously adopted. If several stretchers are in progress, each with two bearers only, one may be laid on the ground while the two bearers quit it to give temporary aid to the bearers who have to carry the first stretcher across the obstruction. If it be a hedge or fence which has to be crossed, one of the bearers first gets across, and the stretcher, supported by three others, two on its opposite sides in advance and one in rear, is raised sufficiently high for the front handles to be passed clear of the obstacle, and over it, so that they can be taken by the bearer who is on the other side. The two side bearers then quit the stretcher-poles which they were holding, cross over the hedge or fence, and are at once ready to maintain the stretcher firm until the rear bearer can also cross. The stretcher being then laid on the ground, the other stretchers can be got across in a similar manner. Each stretcher can now be taken charge of by the two bearers who were previously carrying it, and the march resumed. The passage of a broad dike can be effected in a very similar manner, and with safety to patients, under corresponding circumstances.

RULE 15. On no account should a stretcher be permitted to be carried on the shoulders of four men. The evil of such a proceeding is not only that it is unlikely the four men will be of precisely the same height, so that a level position may be secured, but also that the wounded person, if he should happen to fall from such a height, owing to the helpless condition in which such a patient usually is, is not unlikely to sustain a serious aggravation of the injuries he may already be suffering from. General Stonewall Jackson of the Confederate States army, during the war of the rebellion, apparently owed his death to neglect of this rule.

He was being removed, wounded, from the field of action on a stretcher, which was carried on the shoulders of four bearers. One of the bearers, while engaged in this duty, was shot and fell, and the General was immediately thrown off the stretcher. The suddenness of the event, and the height from which he fell, caused General Jackson to come into contact with the ground with such force that the character of his wound, which was by no means a mortal one, was aggravated by the blow, and the General sustained, in addition, a severe concussion of the chest, which was followed by inflammation, and appeared to be the immediate cause of the fatal termination which ensued. The same cause led to a deplorably serious wound happening to Colonel Unett, who commanded the 19th Regiment during the Crimean war. He had sustained a very serious gunshot fracture of the thigh at the final assault of the Redan, and was being carried up to camp on a stretcher, which was unhappily placed on the shoulders of four of his men. One of them stumbled on the way, and the jerk by some means caused the discharge of the man's loaded rifle. It was being carried bandoleer fashion at the time, and the bullet in its course passed through the neck of Colonel Unett and shattered his right clavicle. I attended my unfortunate commanding officer until his death, which occurred a few days afterwards from the effects of his multiple wounds. Moreover, one of the bearers of a stretcher ought always to have a patient suffering from a grave wound in view, so as to be aware of hæmorrhage, fainting, or other change requiring attention, taking place; and this cannot be done when the patient is carried on the shoulders. The height, too, is calculated to cause the patient uneasiness and fear of falling off, which it is also desirable to avoid. For all these reasons, notwithstanding that untaught soldiers will often attempt to carry a patient on a stretcher upon their shoulders, from the weight being borne more easily in that position, or with a view of relieving a fatigued condition of the arms, the proceeding should be strictly forbidden.

Rule 16. If the wounded man lying upon a stretcher have to be transferred into an ambulance waggon, a third bearer must be employed to assist in the transfer. This is already provided for if three bearers accompany the stretcher. On the arrival of the stretcher at the waggon, the bearer near the part which is first to be inserted should be ready to move round the end of the pole in his left hand, retaining, while he does so, the support of this pole only. Before he makes this move, however, the third bearer must grasp the right-hand pole; the hold of the other pole should on no account be given up by the first bearer until he has quite ascertained that the right-hand pole is fully supported by the third bearer. When this is known to be accomplished, the first bearer turns round, supporting the left pole at the side as he does so, and then, acting in concert with the third bearer, the two

together raise the ends of the poles, which are now free, into the compartment of the waggon which is destined to receive them. The bearer at the head of the stretcher at the same time takes care to maintain it level, and assists in effecting its entrance into the waggon by pushing it forward. By adopting this method the admission of the stretcher is effected with ease, rapidity, and perfect security; while two bearers can only accomplish the object with difficulty, and not without risk of accident to the patient.

(B.) *Wheeled Stretchers.*

General remarks on wheeled stretchers.—Stretchers supported and moved on wheels are articles of ambulance transport of comparatively modern invention. They were employed for the first time as military means of transport in the German war against Denmark in 1864; and the experience then gained led to very warm expressions regarding their utility by both Prussian and Austrian army surgeons. Wheeled stretcher supports have only formed part of the regular ambulance equipment of the British service since the report of the Committee on Ambulance Conveyances in the year 1872.

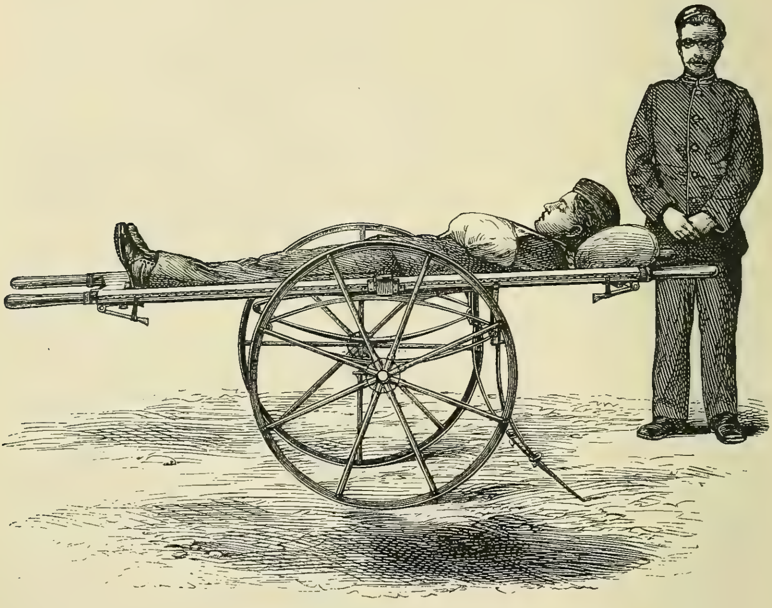
Wheeled supports for stretchers have been designed with a view to supply means of making up for the deficiency of bearers which has always been experienced when wounded men in large numbers have had to be carried by hand stretchers, as well as to diminish the labour and fatigue entailed upon the bearers who are engaged in their removal. Under particular circumstances, when the nature of the ground is favourable for their employment, they offer other important advantages; especially that of effecting the removal of the wounded more rapidly than it can be accomplished when the stretchers are carried by hand—thus saving them from prolonged exposure, and affording them an opportunity of more early surgical assistance.

The experience of the war between Germany and France in 1870–71 did not tend to confirm the good opinions which had been previously held regarding wheeled stretchers as conveyances for wounded men near the scene of conflict. A certain number of them were taken into the field with the German sanitary detachments, but it was found that they could very rarely be used with advantage between the fighting lines and the field hospitals. In consequence, in Germany, it has since been determined to discontinue them among the articles of equipment of the *sanitäts detachements*, and to retain them for use only with intermediate and stationary hospitals, and in garrisons. These appear to be the more practicable spheres for their employment in time of war; at the same time, they can always be made use of with advantage wherever level roads exist, when sufficient ambulance waggons are

not available, and it is a matter of importance to save the time and labour which would otherwise have to be expended in the carriage of sick or wounded men by hand. They could doubtless be turned to very useful account in the home country in case of an invasion. Various forms of these conveyances are in constant use in civil life.

A wheeled stretcher consists of two distinct parts—the stretcher and the wheeled support. In respect to the stretcher, the adaptation of the same one which is used for hand conveyance to the wheeled support presents so many obvious advantages that it has been adopted as a principle in the construction of the wheeled

Fig. 67.



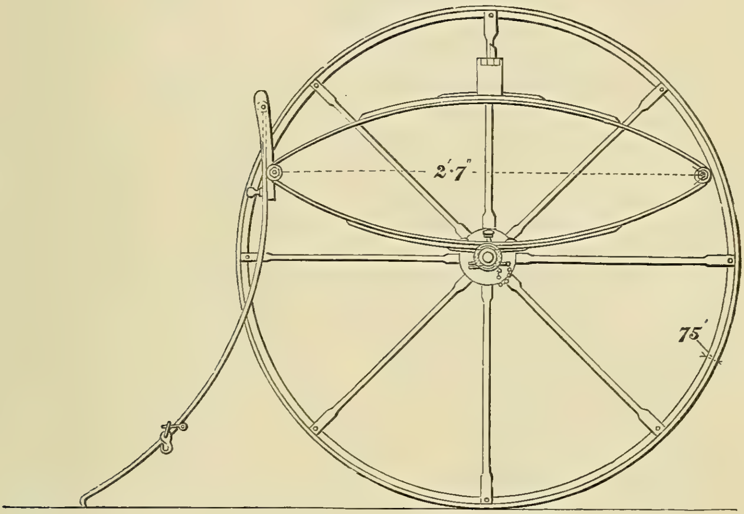
Wheeled Stretcher Complete.

stretcher of the British service. There are other points of importance to be attended to in the construction of a contrivance of this kind for military purposes. It must be made capable of being easily taken to pieces for stowage, and of being easily put together again when required for use. It must be strong enough to stand rough usage, but must be light enough to be lifted by two men over a ditch, bank, or low wall in case of need. The mode of connection between the stretcher and the wheeled support must be simple, so that the stretcher with a patient lying on it may be placed on the support or taken off it with ease and celerity. The

position of the stretcher on the support must be so arranged, and the weight adjusted, that the whole may be readily either drawn or pushed by a single bearer, at the same time that the wounded man upon it has as much security and ease as practicable. These principles have all been kept in view in the construction of the British service pattern.

Wheeled stretcher of the British army.—The 'stretcher' is the regulation field stretcher described at page 631. The stretcher shown in the drawing (fig. 67) is the one which was introduced by the Hospital Conveyance Committee in 1872; the service stretcher which is in present use, with rollers for feet, is equally

Fig. 68.

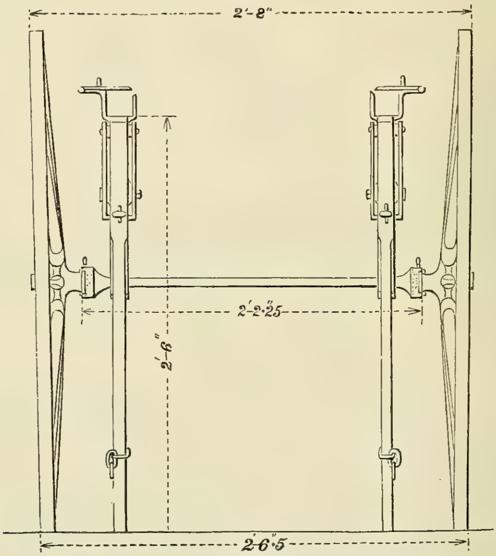


Sectional side view of Wheeled Stretcher Support, with measurements.

adapted to this mode of carriage. The 'wheeled support' is composed of steel and iron throughout, and is therefore not liable to deterioration from long storage. It consists of an axletree, a pair of wheels, a pair of elliptical steel springs with crutches on their upper surfaces to receive the stretcher-poles, and a pair of folding legs. The axletree is made of $\frac{3}{4}$-inch square steel, with a metal cap at each shoulder. The wheels are 3 feet in diameter. Each consists of eight steel spokes, deeply hollowed on opposite sides, screwed into a wrought-iron nave, and riveted to a T-iron tire 1 inch in width. The nave is made to secure the wheel on the axletree arm. The springs are made from $1\frac{1}{4}$ by $\frac{1}{4}$ inch spring-steel, and are each two leaves in thickness. On the top of each

spring is a galvanised iron crutch to receive the stretcher-pole, with a hinged flap and turn-stud to secure it when in motion. When the wheeled stretcher is required to be stationary, the hinged flap just mentioned is folded back, and it then forms a stop for the wheels by including one of the spokes in a notch on its end. At the bottom of each spring is a clip, with a stud, split key and chain, to secure it to the axletree. The legs are attached to the rear of the springs by a double joint, and are curved so as to fold over the springs when packed. They assist in keeping the stretcher in a horizontal position when the support is stationary. When not required for use, they are lifted

FIG. 69.



Front view of Wheeled Stretcher Support, with measurements.

up, and each secured to the corresponding side-pole by a shackle and hook. The height of a stretcher when placed on the support is 2 feet 7½ inches.

The weight of the wheeled support without the stretcher is 74 lbs. 13 oz.; with the stretcher of former pattern upon it, 100 lbs. 5 oz.; with the roller stretcher, 106 lbs. 13 oz. The whole is made to take to pieces and to pack up in a small space for stowage. A canvas cover or case is provided for it. As bearers must be trained in order to carry patients on hand stretchers properly, so they have to be instructed in quickly unpacking and putting together the stretcher support, and in using it in connection with the

stretcher when a wounded man is to be conveyed by it, or to be transferred from it to an ambulance waggon.

(C.) *Mule Litters and Cacolets.*

General remarks on mule litters and cacolets.—These are conveyances borne by mules, and only designed for use in mountainous countries, where the roads are not practicable for wheeled conveyances, and where the distances are too great for transport by hand stretchers. They do not form part of the ambulance transport equipment of the British service under ordinary circumstances of campaigning. The litters are for patients requiring a recumbent position; the cacolets for patients who are able to be carried in a sitting posture. They are employed in pairs, and their construction adapts them for being hooked on to the pack-saddles of general service pattern, one on each side.

Mule cacolets and litters were first introduced as articles of ambulance equipment in the French army in Algeria. Had it not been for these contrivances, the French wounded in many of the expeditions in the mountainous parts of that country could not have been transported from the scene of action to a hospital; and no less an authority than Marshal Bugeaud was led to say, that Algeria could hardly have been conquered without them, such would have been the dispiriting influence on the troops if they could not have felt secure that they would be saved from the Arabs in case of being wounded. Finding these means of conveyance of such practical value in Algeria, the French subsequently adopted them as the principal forms of their ambulance transport for general service. When not required to carry sick or wounded patients, both cacolets and litters admit of being folded up flat against the sides of the mules; and other packages, such as boxes of biscuits, can be slung and carried over them. In this way stores can be carried to the front, and sick men brought away to the rear, on the same mules. Mule litters and cacolets were introduced among the articles of English ambulance equipment during the Crimean war. They were found to be very useful in the Crimea for carrying the wounded along the narrow ravines leading up from Sebastopol, and also for conveying them from the camps to the ports of embarkation, before roads suitable for wheeled vehicles existed.

Only strong and large-framed mules are suitable for the carriage of wounded men on litters and cacolets. The animals also require training, as well as their conductors. The men of the Medical Staff Corps go through a course of drills and exercises with cacolets and mule litters at the Training Depôt at Aldershot. They are taught to saddle and unsaddle the animals with expedition; to prepare, hook, and unhook the cacolets; to load and unload

them systematically with patients; and to lead the animals when carrying patients over various descriptions of ground. A similar training is undergone with the mule litters. Much practice is necessary to fit men for performing these duties when weak and disabled men are to be conveyed, so that they may be conveyed with the necessary care, consideration, and adroitness. The motion

FIG. 70.

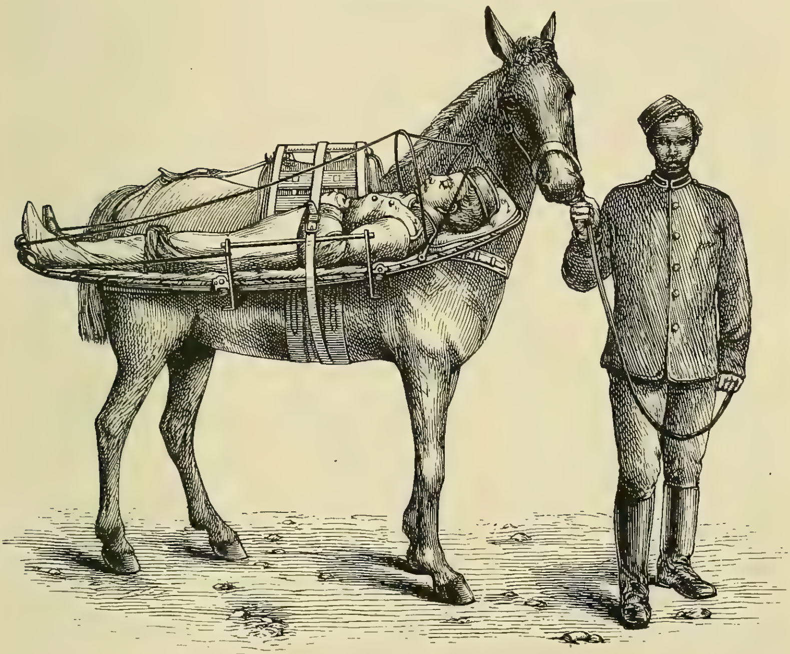
Mule Cacolets.

communicated to the litters when the mules are walking is peculiar. It is quite different from the jolts or concussions that a patient is liable to meet with in a wheeled vehicle; it is a sort of pitching motion, and, with some persons, creates a feeling akin to sea-sickness. Two well-trained mules carrying wounded can be coupled by means of a chain, one in front of the other, and in

case of need conducted by a single soldier holding the bridle of the first mule.

The mule cacolets of the British service.—These cacolets are made of wrought-iron and are simply folding-chairs, arranged for being hooked to the two sides of a pack-saddle. Each cacolet can be placed either on the right or left side of the pack-saddle, and each forms a seat for one patient. A footboard is attached to each cacolet. A broad strap crossing the patient in front assists in keeping him steady in his seat. The weight of a pair

FIG. 71.



Mule Litter.

of cacolets is 56 lbs.; the weight of the present general service pattern pack-saddle, known as size No. 1, is 46 lbs. The drawing (fig. 70) will furnish a better idea of this mode of conveyance than a more lengthened description.

Mule litters of the British service.—These conveyances are also made of wrought-iron. The framework of the litter is jointed into three principal divisions, so that the whole may be folded up in a compact form when not in use. Each litter when extended is about $6\frac{1}{2}$ feet in length. The bed of the litter is

made of strong canvas secured to the frame by cords. There is a canvas hood which can be raised at pleasure for purposes of shelter against rain or solar heat, while a canvas apron attached to the foot of the frame can be drawn upwards so as completely to cover a patient. The hood and cover are omitted in the drawing (fig. 71), in order to convey a better idea of the position of a patient lying on one of these conveyances. The weight of a pair of litters of the latest pattern, complete, is 106 lbs.[28]

(D.) *Sick-Transport Waggons.*

General remarks on sick-transport waggons.—Ambulance sick-transport waggons are four-wheeled vehicles specially constructed for the transport of sick and wounded soldiers. Their construction does not adapt them for the carriage of heavy stores. In some armies vehicles have been constructed to serve the double purpose of carrying either stores or patients; and if the same conveyances could be made equally suitable for bearing great weights, and for the safe and easy carriage of wounded men, in regard to the adjustment of springs, the required internal fittings, and the necessary means of protection for patients, it would manifestly be a desirable arrangement on the score of economy. But all attempts to secure the two results in a sufficiently satisfactory way have hitherto failed. Moreover, experience has too often shown that when sick-transport conveyances have been permitted to be used for other purposes in military service than those for which they have been specially designed, practically they have seldom been forthcoming when they have been required for the sick and wounded. As a matter of course, on occasions of need, when regular ambulance waggons are not available, or not available in sufficient numbers, any vehicles that can be obtained, however unsuited for sick persons they may be, must be substituted for them rather than delay the removal of wounded men to a hospital; and it should be remembered that there are many plans by which the worst inconveniences attendant on the use of springless carts and rough waggons for men suffering from wounds may be materially lessened.[29] Some adaptations of country carts and general service waggons to fit them temporarily for the transport of sick and wounded men are systematically practised by men of the Army Medical Staff Corps at the Training School at Aldershot.

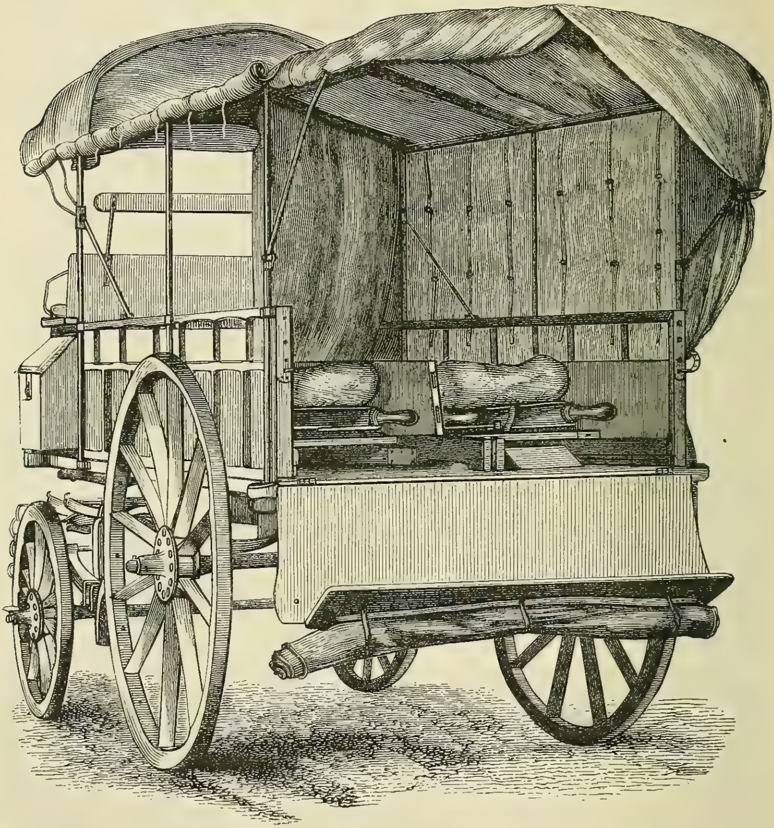
The relative advantages of two-wheeled and four-wheeled vehicles for ambulance purposes have been much discussed by military surgeons. On the whole, the greater stability of the waggon as compared with that of the cart, its security notwithstanding an accident happening to one of the horses, and its freedom from the movement which results from the connection

between the shafts and body of a two-wheeled vehicle, have been thought sufficient grounds for deciding in favour of waggons for sick-transport purposes in the British service.

Ambulance waggons in the British service.—Several forms of ambulance waggons exist among British ambulance equipment. This variety arises from the fact that as alterations are made from time to time in conveyances, although the latest pattern approved is fixed as a guide for the construction of all fresh vehicles from the date of sanction, the use of the vehicles of previous patterns, so long as they are in good condition, is not abandoned, from motives of economy. Thus there are five ambulance waggons, differing in certain details, which may be met with. They are distinguished in the service as Mark I. to Mark V., the last-named having been only approved for use as recently as the year 1889. Mark I. and Mark II. waggons were introduced as improvements on some which had been employed during the Crimean war, and have now practically disappeared from use. The diameters of their fore and hind wheels were alike, and hence they were known as equirotal waggons; they had special 'waggon stretchers,' fitted with springs on a frame, and rollers for easy movement in and out of the waggons. These waggons were not found to be successful when employed on service abroad, although they had answered well on the level roads in home service. In consequence of the failure of these conveyances, the construction of a new waggon was submitted by the Secretary of State for War to the committee before alluded to, which was appointed to consider the whole question of hospital conveyances, and in 1872, after numerous experimental trials, this committee recommended, and the War Department sanctioned, the form of ambulance waggon which has been in chief use since that date, and which is shown in the illustrations which follow. This waggon, in which the equirotal system was abandoned, as was also the use of special 'waggon stretchers,' has been since known as Mark III., and after the introduction of the stretcher generally spoken of as the 'Faris stretcher,' as Mark IV. The special features of the waggon approved for guiding future supplies, distinguished as Mark V., will be again referred to farther on. The ambulance sick-transport waggon of the Hospital Conveyance Committee was designed for draught by two horses. At the same time, appliances are provided for attaching two others, in case that animals of sufficient strength for the load cannot be obtained. The waggon is arranged for accommodating two slightly wounded men, together with the driver, sitting in front; two badly wounded lying on stretchers in the body of the waggon; and two slightly wounded, together with a hospital attendant, seated behind, leaning against a back-board, and resting their feet on the ledge of the tail-board. A leathern apron serves for cover. It can be either driven from

the box, or the driver can ride and drive, as in most other military vehicles; all the appointments are provided for either mode of conducting the waggon. The diameter of the fore-wheels is 3 feet; of the hind-wheels 4 feet 8 inches. The reduced diameter of the fore-wheels is to enable the waggon to turn on its own ground. This could not be done with the waggon of the previous

Fig. 72.

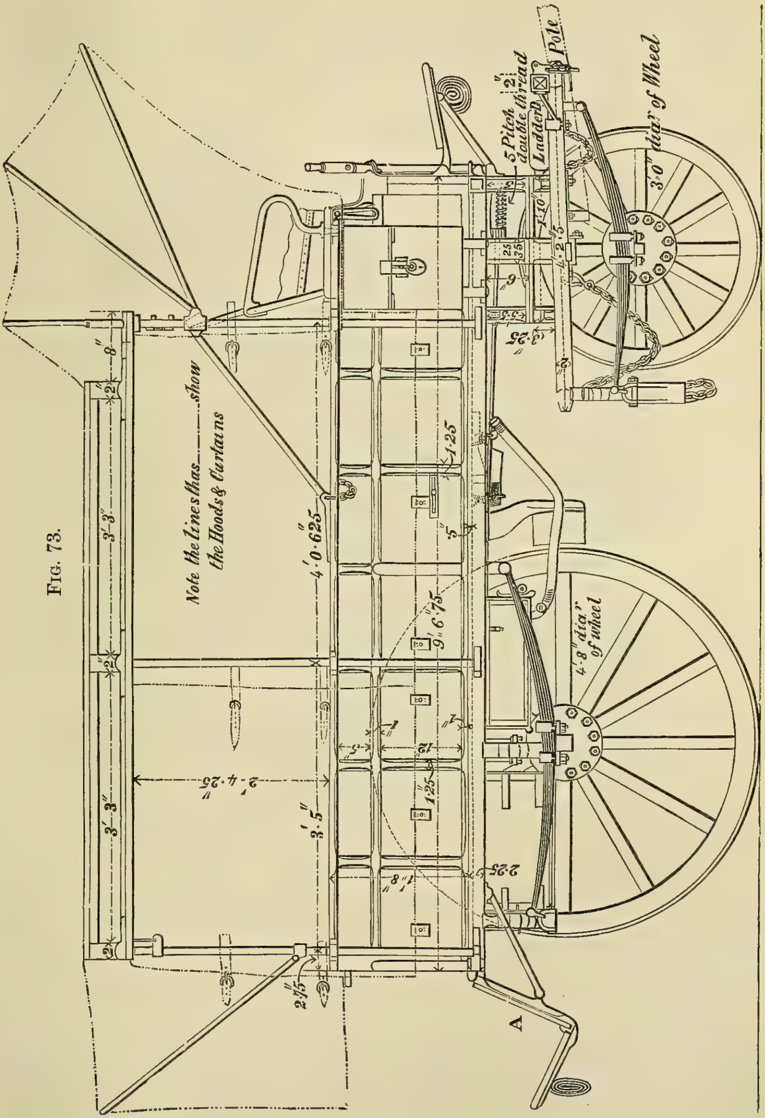


Perspective view of the Hospital Conveyance Committee's Ambulance Waggon.

pattern, as the front and hind wheels were of equal diameters. The increased draught from the reduction in size of the fore-wheels is counterbalanced by less weight being thrown on them; the weight of the waggon when loaded with patients having been so distributed by the committee who designed it that the pressure on the fore and hind wheels was in direct proportion to their

respective diameters. The springs are semi-elliptical, carefully adjusted to the weight to be carried; a cross check spring being

FIG. 73.



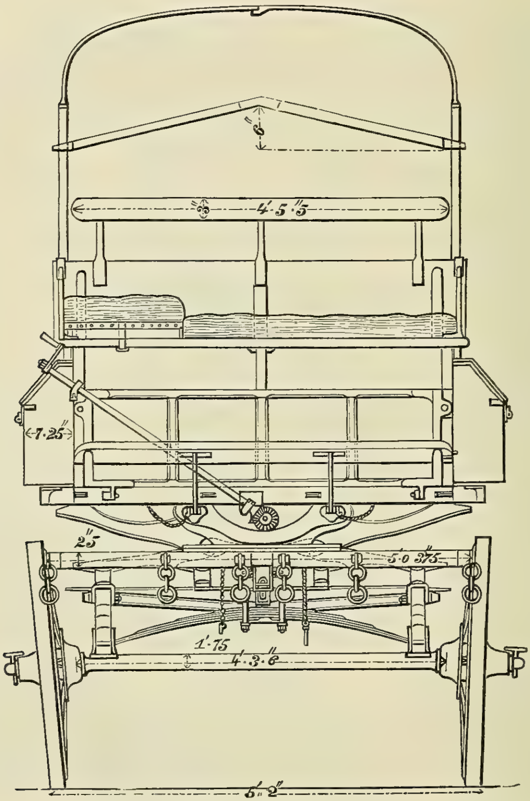
Side elevation of the Hospital Conveyance Committee's Ambulance Waggon, with measurements.

added behind to come into play when the full complement of men are placed in the waggon. A break acting on the hind-wheels is worked by the driver from his seat in front; and a drag-shoe is

suspended from the near futchell of the fore-carriage. A zinc tank, cased in wood, and able to hold nearly ten gallons of water, is fitted beneath the floor of the waggon. A stop-cock, long leathern tube, and a funnel are attached to it.

Behind the water-tank is a locker for forage and utensils; it is accessible through the floor of the waggon by two padlocked

FIG. 74.

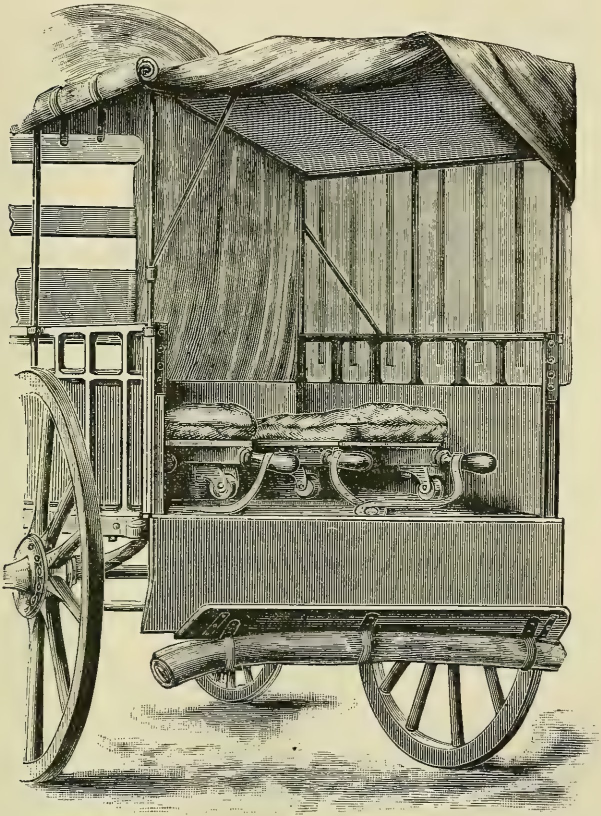


Front elevation of the Hospital Conveyance Committee's Ambulance Waggon.

trap-doors. The available floor space inside the waggon is 9 feet $5\frac{1}{4}$ inches by 4 feet 3 inches. The height of the sides of the waggon is 1 foot 8 inches; they are boarded for the first 14 inches, and open from the middle to the upper rave, about 5 inches. The portion of the floor for the recumbent patients is divided longitudinally by an upright board 14 inches high. Special fittings were originally provided to facilitate the insertion

of the two stretchers, but these fittings were removed in the Mark IV. pattern, and the present service stretchers were simply rolled in and out on their wheels upon the floor on each side of the partition (see fig. 75). The roof of the waggon is framed, and hinged in the centre to facilitate package. It is supported on tubular iron standards. Straps are attached to these standards for carry-

FIG. 75.

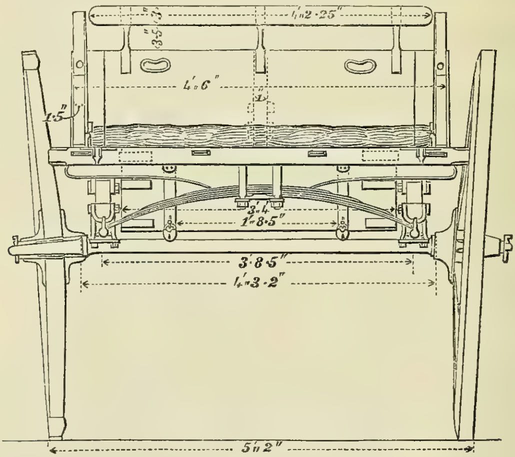


Interior of part of the Hospital Conveyance Committee's Ambulance Waggon with the present Service Stretchers inserted.

ing two spare stretchers on each side, on the top of the side-rail of the waggon. These stretchers are carried rolled up; the pillows belonging to them are secured by straps to the ridge-pole of the roof. The framed roof is filled in with double canvas, the two layers being fastened together by indiarubber solution. It is thus rendered impervious to rain. The sides are of single canvas, arranged

to be fixed down, or rolled up to any required height at pleasure. Places are provided for the valises of the wounded men between the stretcher-handles, before and behind. There are also loops fixed to the floor of the waggon for securing the rifles of the wounded men. It is of course very necessary, before depositing these weapons, always to ascertain that they are not loaded. The weight of the waggon and fittings is a little below 18 cwt.; the calculated weight when loaded with eight persons and their kits, a little over 30 cwt. This is a manageable weight for draught by two horses; regard being had to the fact that, as a rule, the waggon will only be required to move over made roads, and not faster than at a walking pace.

Fig. 76.



Rear elevation of the Hospital Conveyance Committee's Ambulance Waggon.

A special difficulty, which has been before referred to, exists in respect to every vehicle belonging to the British army, and influences all the details of their construction. Owing to the insular nature of Great Britain, all army equipment, to be available for military operations in a foreign country, must be capable of being carried by sea. An ambulance waggon has therefore itself to be made portable. To effect this object the waggon is made so as to be readily taken to pieces, folded up, and formed into a convenient package for stowage on board ship.

A practical illustration will show the importance of this arrangement. During the late Franco-German war the 'British National Society for Aid to Wounded in time of War' obtained from the War Office twenty ambulance waggons, for use with the

ambulance sent to France under the direction of Deputy Inspector-General Dr. Guy. Eight of these ambulance waggons were for transport of wounded, and twelve were general service waggons adapted for the transport of stores. All these vehicles were made up into packages, and placed on board ship at Woolwich. They were accompanied by some non-commissioned officers and twenty privates of the Army Hospital Corps, who had been trained in their use and particular construction. On arrival at Havre, the packages were got out of the hold of the vessel and placed on the wharf. They were then unpacked and the different parts put together. The work was carried out with regularity and despatch, and the twenty waggons, complete in all respects, were ready to proceed on the road under five hours from its commencement. Had the attempt been made to convey the vehicles over the comparatively short distance between the Thames and the French coast in their ordinary condition, not only would the vessel which conveyed them have been insufficient in size for their accommodation, but those which it could have carried would scarcely have escaped from being damaged during the voyage. Objections have been made to the solid, and therefore proportionally heavy construction of British ambulance waggons. But the advantages of their solid construction were also exhibited in the instance just noticed. The twenty waggons were subjected to very severe usage during the whole of the trying winter of 1870-71; yet, in the following spring, they returned to England in so serviceable a condition that the Government readily consented to repurchase them from the Society to which they had been sold.[30]

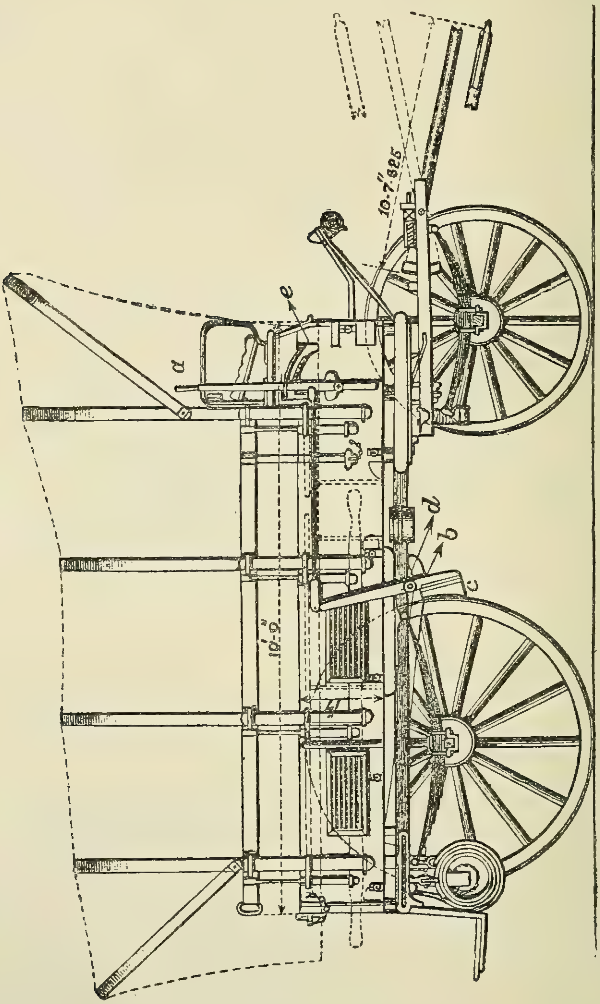
The pattern on which ambulance waggons are now being constructed, distinguished as Mark V., differs in various particulars from the patterns just described. It has hinged seats fastened along the sides within the body of the waggon, so that it can accommodate altogether, including 2 seats in front, 12 men seated when stretchers are not used, or, when stretchers are used, 2 men lying down, and 4 men sitting on the 2 front seats. The seats along the sides of the waggon are folded up out of the way when stretchers are inserted.

The waggon is fitted with a perch, and a mechanical arrangement known as 'Jacob's lock fore-carriage,' by means of which larger front wheels can be used, and the strain on the body of the vehicle and on the horses when travelling reduced. While the fore-wheels in the Conveyance Committee pattern (Mark III. and Mark IV.) had a diameter of 3 feet, so that they could lock under the body of the waggon, the fore-wheels in the Mark V. pattern are 3 feet 9 inches in diameter. The small size of the fore-wheels in the previous pattern enabled the waggon to turn on its own ground, occasionally a great advantage; the minimum

space on which the Mark V. waggon can turn is 30 feet 7 inches. The hind-wheels in both patterns are 4 feet 8 inches in diameter.

The seat in rear for wounded men able to maintain a sitting posture no longer exists in the Mark V. pattern; but, in its stead,

Fig. 77.



Side elevation of Mark V. Ambulance Waggon.

a portion of the body of the waggon in front is partitioned off, and provided with seats for two such patients. To get to these seats, they must cross the driver's seat, the back rail of which can be folded out of the way to enable the passage to be made. A

wooden ladder is carried to assist patients in mounting; it is strapped to the under part of the waggon when not in use. A cask to hold 10 gallons of water is secured by iron bands under the rear of the waggon.

A brake, worked through a hand-lever (*a*) by the driver's seat, acts by connecting rods and block (*c*) on the front of the hind-wheel; while a connected cross-bar and lever act on a similar block against the near wheel. There are two lockers beneath the driver's seat. The outline illustration (fig. 77), which is copied from the Manual for the Medical Staff Corps of 1893, will indicate the other features of this ambulance waggon better than further description.

(E.) *Railway Hospital Trains.*

General remarks on railway hospital trains.—The railway transport of sick and wounded in time of war has been immensely developed in the last twenty years. It was largely used during the United States great civil war, and also in the Bohemian war of 1866; but was more than ever employed during the war between France and Germany in 1870–71. The wounded were removed in ordinary goods trucks and waggons, and in passenger carriages temporarily adapted to ambulance purposes; but also, in some instances, in complete ambulance trains specially built for the carriage of sick and wounded troops, and furnished with an entire hospital equipment. Carriages and trains of the latter description, of various patterns, formed conspicuous objects in the sanitary department of the Vienna World Exhibition of 1873, and in the Sanitary Exhibition at Brussels in 1876, and have continued to appear on later occasions in other parts of the Continent, down to the Medical Congress at Rome in 1894. It is not to be expected that similar railway ambulance trains, with pharmacy and cooking vans, surgeries, and all the stores of dressings and appliances necessary for prolonged treatment, would be provided in Britain; the great expense that would be entailed in their construction and fittings would not be justified by any prospect of sufficiently beneficial results. In case of a number of sick and wounded having to be removed by railway in this country, a very limited medical and surgical provision for the journey will suffice until a relief station or established hospital is reached; but whether the transport be short or long, it is equally necessary that it should be performed without entailing additional injury, or pain that can be avoided, on the sick men during their conveyance. It is therefore a subject which requires particular attention at home as well as abroad.

If ever an invasion of any part of Great Britain should be attempted, and a conflict ensue on her shores, the welfare and safety of many of the wounded will be materially influenced by

the nature of the arrangements for their conveyance to the hospitals in the interior. It is by the railways that the great proportion of the wounded will have to be removed. Improvised railway conveyance of badly wounded men has hitherto been too often attended with a painful aggravation of their injuries, and increase in the gravity of their general condition. Great attention has been given to the systematic entraining of field medical establishments, including the sanitary or bearer companies, and field hospitals, with their respective conveyances, draught-animals, &c., as well as to various details for lessening the drawbacks of railway ambulance transport by Continental nations, because in the wars by which they have been visited, they have had practical experience of the importance of the subject; but comparatively little consideration has been given to it in our own country. In the year 1870 I was requested to draw up a plan for the transport of sick and wounded invalids by railway from Portsmouth to Netley. The journey was at that time rather a long one, often occupying five or six hours, from obstructions by other trains and other causes—the direct railway line not having then been constructed. Many of the invalids reached Portsmouth from India and other stations abroad in an extremely weak and critical condition, so that complete hospital care and attention were needed during the journey. A design was submitted for a carriage in which eight patients could be carried lying down, with accommodation for a surgeon and attendants, and the plan being approved, the carriage was constructed under the superintendence of the Royal Carriage Department. In the year 1886 a second carriage, on the same general plan, was added, and these two have been constantly employed in the service for which they were designed up to the present date. The chief features of the ambulance carriage first constructed were—(*a*) a side-entrance with folding doors wide enough for a stretcher 8 ft. long to be carried into, and turned round in the carriage with ease; (*b*) eight bunks, four on each side of a central passage, on which eight stretchers could be placed, and secured from movement; (*c*) a locker for medicines and surgical materials under a seat provided for a medical officer; (*d*) a stove and kettle, so that hot water might be constantly ready, and the carriage warmed in winter; (*e*) hinged seats for attendants; (*f*) end doors, with sliding bridges over the buffers, for communication with adjoining carriages; (*g*) a W.-C. connected with a water-tank on the roof; and (*h*) a lavatory and sink opposite to the W.-C. The W.-C. and lavatory were omitted in the second ambulance carriage added in 1886, as there was free communication between the two carriages by means of the end doors and bridge between them. These carriages, however, would not form guides for the provision which would have to be made for general use in this country on the occurrence

of war. It would be impracticable to construct such carriages in sufficient numbers, or, if constructed, to ensure their presence at the particular points where they would be required in case of a landing on our shores being attempted, and a battle ensuing. The chief problem which requires to be solved is how best to convert the existing waggons, such as may be found at any railway station, and especially those which are likely to be used for carrying baggage and stores for an army, into suitable carriages for the removal of wounded men. Such converted waggons must comprise ready accessibility of the patients to surgeons and attendants, proper available supports for them, together with as much freedom from injurious movement as is possible; while, at the same time, due regard should be had to economy in cost, mechanical simplicity, sufficiency of strength, speed of conversion, and to the necessity for so altering the vehicles that they will not be prevented from reverting to their former uses when they are no longer required for hospital purposes. This problem is really only second in importance to that which is known to have received well-judged attention from the military authorities for a long time past, viz., the means of speedily conveying men and guns by railway to any given point, in sufficient force to resist an attempted invasion.

In addition to the ordinary goods waggons which are to be found in large numbers on all railways, there are on some railways specially constructed and fitted sleeping and saloon carriages, which would be especially suited to the necessities of wounded soldiers if they were available at the points where and when they were required. Some officers do not anticipate there would be any real difficulty in obtaining the use of such carriages in case of need. On this point I may quote from the 2nd edition of the Manual of Ambulance Transport an observation by Colonel Findlay of the Engineer and Railway Volunteer Staff Corps, and manager of the London and North-Western Railway. This officer writes: 'I may say, however, that having regard to the large stock of sleeping carriages and invalid carriages, and the ample supplies of bedding of all kinds in the possession of English railway companies, I think there is no reason to doubt that, if ever the emergency should arise, we should be found equal to it, and that we should be able to make up and run suitable ambulance trains for sick and wounded men, with convenient accommodation for doctors, nurses, &c., without any difficulty.' At the same time, it is not to be forgotten that a very large number of railway employés have been trained in the administration of first aid to sick and wounded persons under the auspices of the St. John's Ambulance Association, and that probably the services of a considerable portion of these men could be obtained as attendants on the wounded passengers during their transport.

The mode of conversion of railway luggage waggons, which has appeared to comply most closely with the requirements previously named is one which was designed and described by Major-General Zavodovsky of St. Petersburg. The Zavodovsky system was adopted in 1873 by a commission appointed by the Russian Minister of War to inquire into the question of the transport of wounded by railway in time of war. It was exhibited in the Russian Department of the Sanitary Exhibition at Brussels in 1876. I personally assisted in a series of trials of it under various conditions. On one occasion a luggage van, within which the Zavodovsky supports had been fitted, was subjected to violent jolts and sudden halts; at another time a similar conveyance was attached to a fast train on the South-Eastern Railway, and I found myself, while lying on one of the stretchers, on each occasion subjected to far less disturbance than I had previously supposed this or any other mode of suspension of stretchers in a railway van would have permitted. The necessary articles for carrying the stretchers on this system are so cheap and simple, and so easily stored, that a sufficient quantity can be kept in reserve to meet a sudden exigency without inconvenience or any great expenditure.

The following description and drawing are taken from a pamphlet by General Zavodovsky, and sufficiently explain the means by which the stretchers are suspended. Ordinary service stretchers are employed.

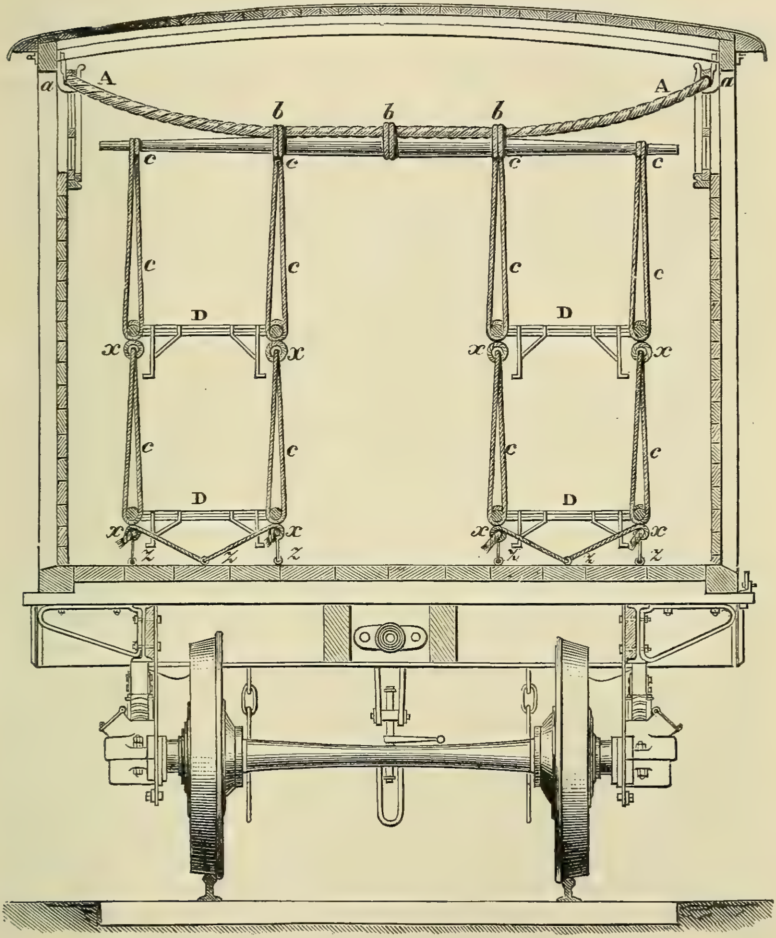
Each set of the appliances will support 4 stretchers in 2 tiers. A single waggon may therefore be adapted to carry either 4 or 8 patients, according to its length. To receive the 4 stretchers, 2 cables (A A) an inch in thickness are suspended across the top of the van, at the requisite distance apart, and secured at each end by iron rings and hooks which are fastened to the side-walls of the van, $2\frac{1}{2}$ inches below the roof. To each of the 2 cables is attached, horizontally, at three points (*b b b*) a pole of any strong springy wood, such as oak, ash, or birch, adapted to the width of the van, but at least 8 feet long. Each pole should be $2\frac{1}{2}$ inches thick in the middle and $1\frac{3}{4}$ inch at the ends. Four ropes (*c c c c*) are now attached to each side of the 2 horizontal poles, with knots (*x x x x*) so arranged that they may support the stretchers (D D D D) on a level.

To prevent the stretchers, when the patients are upon them and the train is in motion, from swaying to and fro, or striking against the sides of the van, the supports of the lower tier of stretchers are lashed to three small iron hooks (*z z z*) or rings screwed into the floor of the van.

When patients are to be inserted, each of the stretchers in succession, with the patient upon it, is carried through the side-door of the van, and the bearers, turning round, at once put them in their places. The first stretcher is put in the upper, the next

in the lower loops of the vertical suspending ropes. Each tier of stretchers is then secured by the lashings to the floor of the van. When the patients are to be removed from the van, the lashings that secure one of the sets of stretchers to the floor are first

FIG. 78.



Section of Railway Waggon fitted with Stretchers on Zavodovsky's System.

loosened. The patient on the lowest tier is first carried out, and afterwards the one above him.

The Zavodovsky plan is now systematically taught and practised in the Medical Staff Corps Training School at Aldershot.

The following stores are there supplied for preparing a goods waggon for the transport of eight patients—viz., 4 cables, 16 ropes prepared with loops, 8 large hooks and rings, 32 small ring-bolts, 4 poles of suitable dimensions, and 28 cords for lashings. The 8 stretchers used are service stretchers.

The results of the experience which has been gained regarding railway ambulance transport on the Continent are well worthy of being studied by British surgeons. The construction, organisation, and administration of railway hospital trains have been systematised in Germany for many years past. In Austria a sanitary school train has been long established at Vienna by the Sovereign Order of Maltese Knights, between whom and the Ministry for War an arrangement has been made for the Order taking charge, in case of war, of 12 sanitary railway trains capable of carrying 160 sick or wounded by each train. These sanitary trains will consist of covered goods waggons, temporarily converted into ambulance carriages. To prepare for this undertaking the Order has built at its own expense a sanitary train of 10 ambulance and 4 other waggons, with a view to the practical instruction, in time of peace, of the officers and attendants who will have charge of the trains in time of war. The technical details for the conversion of the goods waggons into sanitary waggons have been carried out in the Railway Carriage Manufactory at Simmering, near Vienna, upon the general recommendations of the late Baron Dr. Mundy, who was the chief surgeon of the Order. All the arrangements are subject to the sanction and approval of the Ministry for War.[31]

It is obvious that, in case of England having to take part in Continental warfare, her army must depend upon the railway transport of the country in which the military operations are carried on, should the plan of evacuating any of the field hospitals by railway be adopted in it. Railway vehicles cannot be sent from England with an army, as other wheeled conveyances may be. The sick and wounded may be sent from the theatre of warfare in ordinary vehicles to the country of an ally, and thence be despatched by railway hospital trains to a coast; or they may be sent by carriages on railways which have been seized in the hostile country itself. In any case, England must depend, so far as railway hospital conveyance abroad is concerned, on the railways and the carriages found in the countries in which the English troops are operating. It is advantageous, therefore, to be acquainted with the nature of the railway ambulance transport, and the system on which it is arranged to be conducted, in different European countries; but it would be foreign to the purpose of this work to pursue the subject further in its pages.[32]

SECTION X

ON GUNSHOT INJURIES IN GENERAL NOSOLOGY, AND THEIR CLASSIFICATION IN ARMY STATISTICAL RETURNS.

CHAPTER I

ON THE GENERAL NOSOLOGICAL CLASSIFICATION OF GUNSHOT INJURIES

Gunshot injuries in general nosological classification.—The army nosological classification which passed away a few years ago, and which was identical with that devised by Dr. Farr, Registrar-General of England, for the mortality returns of the civil population, comprehended a special class of '*Lesions from violence tending to sudden death*,' under the name '*Thanatici*.' The second order of this class, '*Polemici*,' included all lesions resulting from battle; and among them, of course, the particular lesions produced by gunshot, which were at that time designated 'Vulnera Sclopetaria.' The adjective *sclopetarium* was taken from the word *sclopetum*, a gun—a term which appears to have been first employed about the date of the application of gunpowder to destructive weapons. The celebrated surgeon and anatomist of Padua, Fabritius ab Aquâpendente, writes of leaden bullets discharged from fire-arms as 'globuli plumbei à sclopetis emissi,' and of gunshot wounds as 'vulnera è globulis sclopetorum facta.' Analogous phrases are universally met with in the works of the principal surgeons and authors of the sixteenth and seventeenth centuries. The term *sclopetum* was selected as indicative of the sudden noise produced by the discharge of a gun, and was derived from the Roman *sclopus*, signifying the explosive report produced by a person quickly striking his two cheeks after they have been distended by holding his breath.[1]

The Committee appointed by the Royal College of Physicians of London to draw up the Nomenclature of Diseases, which was first published in 1868, and secondly in 1885, have not made use of this term for a gunshot wound; but, going back to a period before fire-arms were invented, have adopted the expression 'Vulnus ex tormentorum pilis,' as the Latin equivalent for a

wound by gunshot.[2] (*See* Nomenclature, 2nd edit. p. 216.) So far as the word *tormentum* is concerned, it certainly has a more classical origin than the word *sclopetum*, coined from *sclopus*, can claim; but whether it is correctly applied to wounds produced by shot from fire-arms, considering the totally different nature of the Roman *tormenta*, or whether it has any advantage over the familiar Latin equivalent, which has been used by all the writers on gunshot wounds since gunpowder was invented, and is still the ordinary expression in foreign countries whenever a Latin term for gunshot wounds is employed, seems at least to be open to doubt.

In the revised nomenclature of 1885 the committee have grouped injuries into general and local injuries, on the same plan as they have grouped diseases into general and local diseases. Gunshot injuries and wounds are a subordinate group of the local injuries. Gunshot wounds with lodgment of foreign bodies appear under a separate heading, as do also gunshot wounds with complete ablation of a part of the body. In all cases of such injuries the system of classification requires the origin to be specified, whether the gunshot wound is accidental, judicial, homicidal, self-inflicted, or received in battle. The particular agent by which the injury has been effected is also required to be stated. Injuries and wounds are further distinguished according to their locality, either as chiefly involving particular tissues and systems—viz. (*a*) nerves; (*b*) blood-vessels; (*c*) lymph vessels and glands; (*d*) tendons and their sheaths; (*e*) muscles; (*f*) skin and subcutaneous tissue; (*g*) mucous membrane and sub-mucous tissue; or they are subdivided according to certain regional divisions or special organs of the body in which the injuries have happened to occur. The subdivisions named in the nomenclature are—(1) head and face, the injuries of these two bodily regions being again separated and marked A and B respectively in the nomenclature; (2) injuries of the eye; (3) of the ear; (4) of the neck, exclusive of the vertebral column; (5) of the chest; (6) of the back; (7) of the abdomen; (8) of the pelvis and organs of generation; (9) of the upper extremities; and (10) of the lower extremities.

CHAPTER II

ON THE SPECIAL CLASSIFICATION OF GUNSHOT INJURIES IN ARMY RETURNS

Classification and tabulation of gunshot injuries in time of war.—The position of gunshot injuries at large in the general nosological system which is authorised for use in this country has been explained in the previous chapter. A more important matter,

so far as military surgeons are concerned, is the special classification adopted for tabulating particular injuries in army returns when troops are on active service in time of war. Such a classification ought to accord with the circumstances which principally distinguish one set of injuries from another; the conditions which cause them to differ in the phenomena they present, in their consequences, and in the special treatment required for their repair.

The importance of a precise, and at the same time simple, arrangement for classifying and tabulating the wounds and injuries occasioned by war can hardly be overrated. The value of all statistical professional returns depends on the degree in which a truly scientific distribution of the detailed facts and circumstances included in them has been appreciated and carried into execution. It is especially important that this should be recognised in the classified returns with which military surgeons have to deal; and in no part of a military surgeon's practice is this more obviously apparent than in the injuries of war, especially as regards gunshot wounds. In war such injuries often occur in very large numbers together; the occasions are such that surgeons have no time for entering into detailed reports of individual cases; and yet the nature of each case must be defined within certain limits if the records furnished in the statistical tables of the whole collected number of wounds are to be turned to practically useful results, either as regards a study of the surgical consequences of the injuries recorded, their ultimate effects in disabling soldiers for service, or of the comparative results of various modes of treatment. If wounds of different degrees of gravity—some complicated with serious lesions of neighbouring organs, others simple and uncomplicated—are mixed together under one heading, deductions drawn from the tabular returns in which they are included must contain so many sources of error as to be rendered unreliable and valueless for scientific purposes. Yet, almost self-evident as this statement appears to be, it was not until ten months after the first battle of the Crimean war that any authorised classification of gunshot wounds existed in the British service. At the period mentioned, in July 1855, a systematic classification, which had been formed by the late Inspector-General Taylor, C.B., was introduced into the Army Medical Regulations, and it is still the form under which returns of wounds occurring in the field are ordered to be tabulated. Since this was an important innovation, and as not even an approach to scientific accuracy in the general numerical returns of the injuries received in battle existed prior to its introduction, it will be useful briefly to explain the nature of the classification, and to indicate its practical value. Its use will be best understood by taking a brief glance at some of the ill results of the previous absence of any similar system for collecting such statistics.

Field statistical returns prior to 1855.—Previously to the period of the Crimean war, the regulations of the army only required a statement to be furnished by medical officers of the number of gunshot wounds occurring in particular battles and campaigns. This numerical statement had to be rendered to the army medical authorities. No distinction was required to be made between one wound and another in these returns. It was, however, expected that, in the professional reports furnished at stated periods by medical officers, the histories of any injuries of unusual interest should be described at length. It was left to the discretion of the surgeons to select the cases which seemed worthy of being thus reported. Valuable information was sometimes supplied by particular surgeons in this way, but under the circumstances, as might be expected, it was generally very partial in character.

A numerical return of the wounds inflicted in all the early actions of the Crimean war was furnished by the military surgeons. The following was the order on this subject issued at the commencement of the war:—'As soon after an action as possible, medical officers in charge of corps will make out and transmit to the Inspector-General of Hospitals, for the information of the General Commanding-in-Chief, Returns of Casualties made out agreeably to the following form:—

Return of Killed and Wounded in ——Regt. in the Action of——

	Killed.	Wounded.			Total Wounded.	Remarks.
		Dangerously.	Severely.	Slightly.		
Officers . . .						
Non-commissioned Officers and Men						

This form of numerical return was used during the Peninsular war, and no change had been made in it during the forty years which had elapsed since the closing scene of the Duke of Wellington's campaigns at Waterloo. This return was obviously of little professional value. Whether regarded surgically or statistically, it was scarcely in advance of the method of arrangement into 'Mortal' and 'Non-Mortal' wounds, employed by Hippocrates and Celsus; and scarcely so advanced as those employed by some of their successors. Towards the close of the Crimean war, this form of return was expanded and converted into a *nominal* return. In all actions in which British troops have been since engaged, the 'Casualty Returns' furnished by the surgeons in charge of troops or hospitals to the principal medical officer, for the information of the General Officer Commanding

and the Medical Director-General in London, have included the name and rank of each officer, non-commissioned officer, and private wounded, and also the nature and regional situation of his wound; together with its presumed degree of gravity, under the designations slight, severe, dangerous, and mortal.[3] These Casualty Returns have now, therefore, a definite value, for they embody information which may be turned to useful account, not only at the time they are furnished, but also subsequently after the termination of the war. They form reliable records so far as they go.

It sometimes happened, before a set classification was officially appointed, that surgeons in charge of military hospitals classified, of their own accord, in their departmental reports, the injuries from battle which fell under their care. The value of these returns would obviously vary with the professional attainments of the surgeons who compiled them, and the special classification adopted by them. Under the most favourable circumstances, however, in consequence of the partial nature of the information afforded, differences in the plans adopted for tabulating the cases, and sometimes in the professional views held by different surgeons, the returns from these various sources could very rarely be employed with advantage for general purposes or for mutual comparison.

The last year in which any considerable number of soldiers were invalided home to England on account of wounds received in action, prior to the time of the Crimean war, was the year 1848. At that time wounded men were sent from India, New Zealand, and the Cape of Good Hope. The cases of those who were admitted into the General Invaliding Hospital, then at Fort Pitt, were exhibited together in a special numerical return, the first column of which was intended to show the particular regions of the body wounded, and the remaining columns the results of the wounds and the various ways in which the patients were finally disposed of. The first line showed wounds of the head and face together, and I need hardly mention what different considerations are involved in wounds of these two regions. Wounds of the thorax followed; thirdly, wounds of the abdomen; and fourthly, wounds of the back; without any subdivisions to show whether the parietes only, or the cavities and viscera connected with the regions named, were concerned in the injuries. Five lines then followed for wounds of the shoulder, arm, elbow, forearm, and hand; and five for parts of the lower extremity, viz., wounds of the hip, thigh, knee, leg, and foot. There were no indications of there having been injuries of bones, nerves, or arteries, with which some of them were doubtless complicated. To what practical advantage could such information be converted? The numerical returns which have been handed down from the Peninsular cam-

paigns are for the most part equally unsatisfactory in their nature. Inspector-General Taylor made the following remarks in reference to this fact when proposing his own scheme of classification:—'The necessity for some such classification as that now proposed is obvious from referring to the returns furnished during the Peninsular war. These will be found nearly uninstructive, in consequence of the want of distinction amongst wounds of wholly different nature and quality. In wounds of the head, chest, and abdomen, no distinction is made between simple flesh wounds of these regions and injuries to the more important viscera. The returns do not even distinguish between incised and gunshot wounds, which are of such totally different value even in the same parts. All kinds of wounds seem brought together simply as "surgical cases;" and in some of the returns of capital operations it is not clear whether fingers and toes have or have not been included under the terms "upper" and "lower" extremities.' Investigation fully confirms these statements of Mr. Taylor. It is important to be aware of the fact that these uncertainties and serious imperfections do exist in the army professional returns of the Peninsular period.

Classification devised by Inspector-General Taylor.—Inspector-General Taylor's classification was planned with the design of preventing a repetition of the objectionable features of these older returns. Mr. Taylor introduced the classification in India, at the time of the Sutlej campaign, but improved it while he was in medical charge of the 3rd division of the army in the Crimea. Early in 1855 an order was issued for Mr. Taylor's form of descriptive return to be the one used by surgeons in the field, as well as by those on duty in the general hospitals in the rear.[4]

It may be safely asserted that this was the first time a classification of polemical injuries approaching to precision, and at the same time combining simplicity with accuracy of detail and all the requisite elements of practical utility, had been employed in the army returns of any country. In the year 1859, when a new code of regulations for the Army Medical Department was published, this system of classification was embodied in them with some slight modifications; and it still remains the form according to which injuries received in action are required to be enumerated and described by army surgeons. The separate returns furnished by the medical officers in charge of field hospitals and detached bodies of troops are combined in one general return, similarly arranged by the chief medical officer of the army, and despatched to the War Department in England.

All injuries among the non-commissioned officers and men of the army during the Crimean war, which were treated in the field and general hospitals from April 1, 1855, to the end of the war, 7161 in number, have been brought together, and the results of

their treatment shown, by tables arranged in accordance with Taylor's classification, in the official surgical history of the war. The injuries of the commissioned officers have been similarly classified for the whole period of the war. This system of classification had not been officially introduced into India at the time of the Sepoy Mutiny, so that we have no medical and surgical history of that war as we have of the Crimean war; but the cases of all the men among the British forces who were invalided home to England from the effects of wounds have been tabulated according to it.[5] It was equally applied to the injuries inflicted in the field during the last war in New Zealand.[6] No means exist by which the vast number of wounds inflicted during the wars in which Great Britain was engaged prior to the Crimean campaign—in the Peninsula, in Belgium, in India, and elsewhere—can be similarly defined; scarcely anything more than their mere total numbers, and these apparently very imperfectly, were ever recorded. Such omissions can scarcely happen again in any future wars in which this country may be concerned.

The 'Descriptive Numerical Return,' the history of which I have described in the foregoing remarks, comprehends fifteen classes of injuries. The first twelve contain the classification of gunshot injuries; the remaining three classes include wounds from cutting and stabbing weapons, and other miscellaneous injuries. In time of war printed copies of the classified returns are issued to surgeons in forms convenient for the simple insertion of the necessary numbers.

The following is the form of these numerical returns; it is departmentally distinguished as Army Form A 7:—

DESCRIPTIVE NUMERICAL CLASSIFIED RETURN OF WOUNDS AND INJURIES RECEIVED IN ACTION.

Classification and Specification of Wounds and Injuries.			Admitted into Hospital.	Transferred from other Hospitals.	Died in Hospital.	Discharged.		Transferred to other Hospitals.	Remaining in Hospital.
						To Duty.	Otherwise.		
1. Gunshot Wounds of the Head.	1. Contusions and simple flesh wounds of scalp	Slight							
		Severe							
	2. With contusion or fracture of the cranium without depression . .								
	3. Ditto, with depression .								
	4. Penetrating the cranium								
	5. Perforating ditto . . .								

CLASSIFIED NUMERICAL RETURN OF WOUNDS, &c.—*Continued.*

Classification and Specification of Wounds and Injuries.			Admitted into Hospital.	Transferred from other Hospitals.	Died in Hospital.	Discharged.		Transferred to other Hospitals.	Remaining in Hospital.
						To Duty.	Otherwise.		
2. Gunshot Wounds of the Face.	1. Simple flesh contusions and wounds	Slight							
		Severe							
	2. Penetrating, perforating, or lacerating the bony structures, without lesion of important organs								
	3. Penetrating, perforating, or lacerating the bony structures, with lesion of the								
	4. With fractures of the lower jaw								
3. Gunshot Wounds of the Neck.	1. Simple flesh contusions and wounds	Slight							
		Severe							
	2. With injury of the								
4. Gunshot Wounds of the Chest.	1. Simple flesh contusions and wounds	Slight							
		Severe							
	2. With injury of bony or cartilaginous parietes, without lesion of contents								
	3. With lesion of contents by contusion, or with non-penetrating wound								
	4. Penetrating, and ball lodged, or apparently lodged								
	5. Perforating contents .	Superficially							
		Deeply							
5. Gunshot Wounds of the Abdomen.	1. Simple flesh contusions and wounds	Slight							
		Severe							
	2. Contusion or non-penetrating wound with lesion of								
	3. Penetrating or perforating with lesion of								

CLASSIFIED NUMERICAL RETURN OF WOUNDS, &c.—*Continued.*

Classification and Specification of Wounds and Injuries.		Admitted into Hospital.	Transferred from other Hospitals.	Died in Hospital.	Discharged. To Duty.	Discharged. Otherwise.	Transferred to other Hospitals.	Remaining in Hospital.
6. Gunshot Wounds of Back and Spine.	1. Simple flesh contusions and wounds — Slight							
	1. Simple flesh contusions and wounds — Severe							
	2. With fracture of vertebra, without lesion of spinal cord							
	3. With lesion of spinal cord							
7. Gunshot Contusions and Wounds of the Perineum and Genital and Urinary Organs not being at the same time Wounds of the Peritoneum . .	———							
	———							
	———							
	———							
	———							
	———							
8. Gunshot Wounds of the Upper Extremities.	1. Simple flesh contusions and wounds — Slight							
	1. Simple flesh contusions and wounds — Severe							
	2. With contusion and partial fracture of long bones, including fracture of the clavicle and scapula							
	3. Simple fracture of long bones by contusion from round shot . . .							
	4. With compound fracture of . . — Humerus							
	Radius							
	Ulna . .							
	Ulna and Radius							
	All three bones .							
	5. Penetrating, perforating, or lacerating the several structures of the carpus and metacarpus . . .							
	6. Dividing or lacerating the structures of the fingers or thumbs . .							
9. Gunshot Wounds of the Lower Extremities.	1. Simple flesh contusions and wounds — Slight							
	1. Simple flesh contusions and wounds — Severe							
	2. With contusion and partial fracture of long bones							
	3. With simple fracture of long bones by contusion of round shot							

CLASSIFIED NUMERICAL RETURN OF WOUNDS, &c.—*Continued.*

Classification and Specification of Wounds and Injuries.	Admitted into Hospital.	Transferred from other Hospitals.	Died in Hospital.	Discharged.		Transferred to other Hospitals.	Remaining in Hospital.
				To Duty.	Otherwise.		
9. GUNSHOT WOUNDS OF THE LOWER EXTREMITIES. 4. With compound fracture of . . Femur . .							
Tibia only .							
Fibula only							
Tibia and fibula .							
All three bones .							
5. Penetrating, perforating, or lacerating the several structures of the tarsus and metatarsus . . .							
6. Dividing or lacerating the structures of the toes							
10. GUNSHOT WOUNDS WITH DIRECT INJURY OF THE LARGE ARTERIES, NOT BEING AT THE SAME TIME CASES OF COMPOUND FRACTURE							
11. GUNSHOT WOUNDS WITH DIRECT PENETRATION OR PERFORATION OF THE LARGER JOINTS . With fracture of bone .							
Without fracture							
12. GUNSHOT WOUNDS WITH DIRECT INJURY OF THE LARGE NERVES, NOT BEING AT THE SAME TIME CASES OF COMPOUND FRACTURE							
13. SWORD AND LANCE WOUNDS OF							
14. BAYONET WOUNDS OF .							
15. MISCELLANEOUS WOUNDS AND INJURIES RECEIVED IN ACTION .							
Total Wounds and Injuries received in Action							

A return which is anxiously looked for after an action is Army Form A 6, which contains a list of the names of the wounded, together with a brief account of the nature of the wound each has received. This Casualty Return has been previously referred to (see page 670). The following is the form in which it has now to be furnished. One copy of it is ordered to be forwarded by the quickest conveyance to the General Officer Commanding, and one to the Principal Medical Officer for transmission to the Director-General of the Medical Staff at the War Office, as early as possible after each action.

NOMINAL ROLL OF OFFICERS, WARRANT-OFFICERS, NON-COMMISSIONED OFFICERS, AND MEN, WOUNDED IN ACTION AT ______ ON THE ______ 189__.

(The Nominal Roll of Officers wounded is given separately.)

Regiment or Corps.	Rank and Name.	Nature of Wound or Injury.	Slight.	Severe.	Dangerous.	Projectile or Weapon by which Wounds or Injuries were inflicted.						Remarks.
						Gunshot or Shell.	Rifle, Pistol, or Smaller Shot.	Explosion of Gunpowder.	Sword or Sabre.	Lance or Bayonet.	Other Injuries.	
		Total										

(Killed ______. Wounded ______. Missing ______.)

The following are forms of three other descriptive returns—viz. (1) for enumerating and distinguishing the injuries received in action during the period of a week; (2) for showing certain of their hospital results; and (3) the capital operations they may have led to. No. 1 is included in the Weekly Return of Sick among Troops on Active Service (Army Form A 29); No. 2 is a return (W. O. Form No. 151 A) furnished from all hospitals into which patients have been admitted with wounds and injuries resulting from war, and showing numerically the amputations and surgical operations they have led to, as well as the disposal of the patients; No. 3 is a detailed return giving the particular sites of all the surgical operations performed in consequence of the wounds and injuries inflicted. This return is attached to the Descriptive Numerical Classified Return (Army Form A 7), already described.

No. 1.—CLASSIFIED RETURN OF WOUNDS AND INJURIES RECEIVED IN ACTION DURING THE WEEK ENDING ________ 189 __.

N.B.—Separate Returns are used for (1) *Officers and for* (2) *Warrant and Non-Commissioned Officers and Men.*
[*This Form may be used for various purposes where Returns of Wounds and Injuries are to be made, the headings being altered according to circumstances.*]

Dates of Action ________. Places of Action ________.

Regions of the Body Wounded or Injured.	Killed in Action.	Admissions With Wounds or Injuries.							Deaths in Hospital Consequent on Wounds and Injuries received in Action.						
		Total Wounded or Injured.	Projectile or Weapon by which the Wounds or Injuries were Inflicted.						Total Deaths from Wounds or Injuries.	Projectile or Weapon by which the Wounds or Injuries were Inflicted.					
			Gunshot or Shell.	Rifle, Pistol, or Small Shot.	Explosion of Gunpowder.	Sword or Sabre.	Lance or Bayonet.	Other Injuries.		Gunshot or Shell.	Rifle, Pistol, or Small Shot.	Explosion of Gunpowder.	Sword or Sabre.	Lance or Bayonet.	Other Injuries.
1. Wounds of the Head															
2. Wounds of the Face															
3. Wounds of the Neck															
4. Wounds of the Chest															
5. Wounds of the Abdomen															
6. Wounds of the Back and Spine															
7. Wounds of the Perineum and Genital and Urinary Organs, not being Wounds of the Peritoneum															
8. Wounds of the Upper Extremities															
9. Wounds of the Lower Extremities															
10. Wounds with direct injury of the Large Arteries, not being cases of Compound Fracture															
11. Wounds with direct penetration or perforation of the Large Joints															
12. Wounds with direct injury of the Large Nerves, not being at the same time cases of Compound Fracture															
Total															

No. 2.—CLASSIFIED RETURN OF WOUNDS AND INJURIES OF EVERY KIND RECEIVED IN ACTION AT .

Admitted into the Hospital of ________ between the ______ of ________ and ____ of ________, 18__ . .

N.B.—Separate Forms should be used for (1) *Officers and for* (2) *Warrant and Non-Commissioned Officers and Men.*
[*A separate Form may be used for Gunshot Wounds as distinguished from other Wounds.*]

Regions of the Body Wounded or Injured.	Remained on the ——, 18——.	Since Admitted.	Amputations.		Excision.	Other Operations.	Died.	Discharged to Duty.	Transferred.		Remaining on the ——, 18——.
			Primary.	Secondary.					To other Hospitals.	To England.	
1. Wounds of the Head											
2. Wounds of the Face											
3. Wounds of the Neck											
4. Wounds of the Chest											
5. Wounds of the Abdomen											
6. Wounds of the Back and Spine . .											
7. Wounds of the Perineum and Genital and Urinary Organs, not being Wounds of the Peritoneum											
8. Wounds of the Upper Extremities . .											
9. Wounds of the Lower Extremities . .											
10. Wounds with direct injury of the Large Arteries, not being cases of Compound Fracture											
11. Wounds with direct penetration or perforation of the Large Joints . .											
12. Wounds with direct injury of the Large Nerves, not being at the same time cases of Compound Fracture											

N.B.—The Classification will be continued by the expansion of each of these heads, so as to show the precise character of the Wounds and Injuries.

No. 3.—CLASSIFIED RETURN OF OPERATIONS PERFORMED, AND OF DEATHS FOLLOWING THEM.

Nature of Operations.			Operation Performed.		Deaths following the Foregoing Operations.		Diseases or Injuries which necessitated the Operations.	Remarks.
			Primary.	Secondary.	Primary.	Secondary.		
AMPUTATIONS.	Upper Extremities.	Shoulder-joint						
		Arm						
		Forearm						
		Thumbs						
		Fingers						
	Lower Extremities.	Hip-joint						
		Thigh: At upper third						
		Thigh: At middle third						
		Thigh: At lower third						
		Leg						
		Ankle-joint						
		Medio-tarsus						
		Tarso-metatarsus						
		Toes						
EXCISIONS.	Upper Extremities.							
	Lower Extremities.							
EXTRACTION OF BULLETS AND OTHER FOREIGN BODIES								
TREPHINING								
LIGATURE OF ARTERIES								
OTHER OPERATIONS								
Total								

As it will not be possible for the surgeons attached to regiments, under the arrangements which have been described in a previous section of this work, to supply the facts necessary for filling up the foregoing returns, it must devolve on the surgeons in charge of the field hospitals to furnish the required information. The medical officers in charge of the bearer companies may perhaps find the means occasionally of classifying the wounds of some of those who have died on the field without hospital treatment. The information required for the second and third returns must be supplied by the medical officers in charge of the hospitals on the lines of communication and at the base.

Those who care to study and compare the classification which has just been described with other systems of classification, will, I believe, find it to be the most convenient of them all for collecting statistics of gunshot injuries in the field. I have elsewhere suggested a minor alteration in its general outline, for the purpose of obtaining more complete uniformity in the plan, viz., to abstract Class 10, 'wounds of large arteries,' and Class 12, 'wounds of large nerves,' and to transfer them to the list of subdivisions in Classes 8 and 9—wounds of the 'upper' and 'lower extremities.' The tabulation of wounds of important arteries and nerves of other regions, as of the face and neck, is already provided for in the subdivisions of the classes comprehending those regions. By the means suggested, the classes would be reduced from twelve to ten in number. All of them would then be regional, and all the orders or subdivisions structural. If this suggestion were adopted, Classes No. 8 and No. 9 would become subdivided as follows:—

8. GUNSHOT INJURIES OF THE UPPER EXTREMITIES.	1. Simple flesh contusions and wounds.	Slight Severe
	2. With injury of large blood-vessels.	
	3. With injury of large nerves.	
	4. With contusion and partial fracture of long bones, &c.	
	(The remainder as in Taylor's Classification.)	

9. GUNSHOT INJURIES OF THE LOWER EXTREMITIES.	1. Single flesh contusions and wounds.	Slight Severe
	2. With injury of large blood-vessels.	
	3. With injury of large nerves.	
	4. With contusion and partial fracture of long bones.	
	(The remainder as in Taylor's Classification.)	

Other sources of statistical information on the injuries of warfare.—Before concluding the remarks on what has been done in this country towards collecting scientific professional statistics of the injuries from war by classified numerical returns, as well as for establishing a definite system on which the surgical results of future wars in which this country may happen to be engaged can be compared with the results in those which have been previously recorded, it may be mentioned that there are other official documents by which information on the subject is afforded, and by which the professional statistics just described may be checked.

Such are the monthly, quarterly, and annual professional returns and reports from medical officers in charge of hospitals; the special return which every principal medical officer of an army in the field is required to furnish to the Director-General, exhibiting the sickness, casualties in action, and loss from invaliding and other sources, which have occurred in a force from the commencement to the termination of its employment on active service; and lastly, the documents connected with the invaliding of disabled soldiers, and with the pensions awarded to officers and men for disabilities, in which more or less of professional information bearing on the nature of each case is included.

Advantages of the foregoing classification.—Among the advantages of the system of classification which is used in the British service for tabulating the injuries inflicted in war, the following may be mentioned. The attention of surgeons is forcibly called by it to the most important distinctive features of the various injuries that are likely to be brought under their care. If any special complication of wounds are met with that are not already noticed in the classification, they can be readily added without affecting other parts of the return. Facilities are afforded to medical officers for rapidly recording, classifying, and tabulating the injuries by means of the printed forms in which the classification is issued to them; and it also gives facilities to the authorities for collating, uniting, and adding up together in general statistical tables the information transmitted to them by the recording surgeons. The professional observers and operators in the field, and in the hospitals in rear, all classify the injuries that fall under their care on one uniform plan, and it is the same as the one on which the complete statistics will be ultimately shown. The system is thus one of a general division of labour among the whole body of army medical officers, including not only the executive and administrative officers in the field, but also those engaged in the official duties of the headquarters in London.

The statistics of the injuries inflicted in the wars in which other countries have been engaged during the present century have only been published in a few instances, and none of them have been computed under the particular system of classification which has been here described. I have elsewhere compared the respective merits of several systems, and have attempted to indicate some of the advantages that might be expected to accrue to military surgical science, if these differences could be got rid of, and a common agreement come to in different countries for classifying the injuries of war, the surgical operations they lead to, and their results, on one and the same system.[7] The accomplishment of this object is very desirable, if it were only to enable the professional statistics of one country to be easily and reliably compared with those of other countries, to show the relative numbers of

wounds and injuries from particular weapons and missiles, and the effects of treatment in various armies and climates, and thus to encourage the hope that by these means further improvements might be reached beyond those which have already been accomplished. It does not appear as if there ought to be any difficulty in arriving at uniformity in the matter of tabulating the injuries of war which might not be easily overcome. There are certainly no difficulties like those which are encountered when an effort is made to obtain a uniform system of nosological classification of general diseases and injuries. None of the questions and divergent views concerning pathology, nosology, and nomenclature, are present which meet us at every turn when we try to classify diseases and injuries in general in a form which will be acceptable to all surgeons. The wounds and injuries in the instance under consideration are limited in their scope, and do not involve any differences of opinion as regards their nature and origin, so that it is merely a question of their particular grouping, and the number and distribution of the subdivisions of the principal groups, which has to be determined, in order that they may be tabulated similarly in the official returns of different countries in time of war. Beyond doubt the question under notice will be satisfactorily settled at some future time.

SECTION XI

STATISTICS OF GUNSHOT INJURIES IN WARFARE

CHAPTER I

PROPORTION OF HITS TO SHOTS FIRED IN WARFARE

THE increased velocity impressed upon projectiles discharged from the fire-arms of recent years, and the effect of this increase, in combination with other conditions, viz., greater destructive power within certain distances, and a maintenance of wounding capacity beyond the ranges at which former weapons were capable of inflicting wounds, have been elsewhere remarked upon. But in practically applying these facts to a calculation of the number of wounds likely to be actually caused by modern fire-arms and missiles, it is not to be forgotten that, in proportion as arms are improved, the science of defence is also advanced, and military tactics are changed with a view to counteract the purposes for which these improvements are invented. If, on the one hand, the range of rifled small arms be greatly increased, efforts will be made, on the other, by manœuvring the troops at greater distances, by advances in more extended lines and open order, by special employment of artillery, and other military expedients, to neutralise the advantages which the rifles give to the soldiers who are armed with them. Remembering these circumstances, and the vastness of the number of troops who are occasionally brought into opposition in European warfare, with the large space of ground they occupy, we need not expect that the ratios of wounds inflicted to shots fired in a great battle will be shown to be much, if any, greater than it has been in previous wars. The effects produced, indeed, may appear to be even less than they used to be. This will especially be the case when the number of troops held in reserve and out of range of fire is very large, and when in making the calculation, as is frequently done, the general proportion of hits is distributed through the entire force.

Among particular bodies of troops that happen to be brought into opposition within limited distances of each other, or under conditions in which a concentrated fire from an enemy at a distance

happens to fall on a force moving in close order, the effects of the increased penetrative power, force of impulsion, and great rapidity of fire of the new fire-arms will be manifested by a large increase in the numbers that fall killed or wounded, and in a reduction of the time during which these casualties occur. A large proportion of the shots fired under the circumstances named may not only act with fatal accuracy on the individuals first struck, but in many instances, according to the direction of the fire, may inflict wounds on several individuals in succession.

Accidental circumstances which affect the ratios in question. —The relative proportions of hits to shots fired in battle may not only vary according to the nature of the military operations, but a particular conformation of the ground, and other circumstances more or less accidental, will often affect the results. Different kinds of weather even, by altering the surface of the ground in respect to hardness or softness, have been observed to exert an influence on the number of hits produced by shot. The heavy rain which fell during the night of June the 17th, 1815, prevented many wounds which would otherwise have been inflicted in the great battle of the following day; for, in consequence of it, solid shots seldom rose after touching the ground. Shells, too, it is recorded, buried themselves in the soft earth, and, when they sank deeply, generally failed to explode; while, if they did accidentally burst, their fragments were greatly shorn of their power to inflict severe injuries. Similarly, in describing the action at the Taku Forts, at their capture in August 1860, Inspector-General Dr. Muir, the principal medical officer with the British force, wrote: 'Fortunately the ground was soft, and the balls generally buried themselves without rolling or ricochetting, or many more lives and limbs would have been sacrificed.' As an example of an opposite condition, the severe winter of 1870–71, and the frozen hard ground which was the result of it, proved favourable to the Germans in their war against France; for, as the shells fired from their field guns were all percussion shells, they rarely missed explosion, and the number of wounds among the French troops was greatly increased in consequence.

In savage warfare the relative conspicuousness and exposure of the combatants must be taken into account in estimating the wounding effects of particular weapons. Under some circumstances the rudest muskets may produce more hits than the most perfect rifles. In bush-fighting, if the men on one side become exposed on open ground, this fact may be very marked. On January the 24th, 1865, a force of more than a thousand men of all ranks, under Lieut.-General Cameron, moved across the Kaiiwi river, and took up a position at about nine miles' distance from a native village called Nukamaru. Shortly after the arrival of the force, the Maoris made an attack on the picquet which

was advanced to occupy this village. On the English side a staff officer was mortally wounded, three men of the 18th Regiment were killed, and six were wounded. The picquet numbered 250 men, and though they expended 7000 rounds in addition to the 60 rounds of ball cartridge carried by each man in his pouch, altogether more than 20,000 rounds, they did not succeed, it was believed, in killing or wounding one of the enemy. The Maoris fired from under cover, while the British troops were exposed on comparatively open ground. The dark skins of the enemy rendered them invisible in the dense bush, while the white belts of the British soldiers formed good marks for them to aim at. Had the two forces been exposed alike, a very different result would have ensued, as was proved when the Maoris were brave enough to advance and attack the main body of the troops on the open ground in the course of the following day.

The colour of the clothing of troops has been said to influence the number of hits under certain circumstances, as in skirmishing and in firing at long ranges, even when the circumstances of light and general exposure are similar. Colonel Hamilton Smith made a series of experiments to ascertain the vividness of ocular impression produced by differently coloured objects, especially by the colours used for military uniforms. After taking all necessary precautions to ensure similar conditions in his trials, he came to the conclusion that the proportionate liability of their being hit when employed for colouring targets, was—bluish-grey, 5; rifle-green, 7; red, 12. Mr. White Cooper has mentioned, on the authority of an officer of Royal Engineers, that the day before the battle of Vittoria, a Portuguese rifle company under Captain Derinzy, dressed in earthy brown, and a company of British fusiliers of equal strength, dressed in red, had to dislodge some French troops from a bridge. The two companies were equally exposed at the skirmish; and, after it was over, it was found that the loss of the British was as 2 to 1 to that of the Portuguese. This difference was attributed to the much more conspicuous mark afforded to the French by the red clothing of the British than by the brown clothing of the Portuguese. When troops dressed in scarlet are moving in masses, the imposing array, and the striking impression excited by such a bright colour in contrast with the other colours around, may produce a moral effect upon the enemy of an advantageous character to the wearers; but, as regards the chances of being hit when fired at, the scarlet object, relatively to a similar object in bluish-grey, according to the experiments above mentioned, will incur twice the liability to be hit, viz., in the proportion of 12 to 5.

Recorded ratios of hits to shots fired.—It is not often that reliable information can be got as to the exact number of shot and shell fired, so as to compare them with the number of wounds

inflicted in particular battles or wars, and, of course, the exact number of missiles capable of inflicting wounds can never be computed, for the number of fragments scattered by the shells after explosion can never be known. One or two examples will suffice to show that the numbers of wounds inflicted hitherto in sieges and bombardments have been remarkably small in proportion to the numbers of projectiles fired.

According to Drinkwater's Diary of the Siege of Gibraltar, the enemy threw into the garrison, between April 12, 1781, and the following February, 258,387 cannon-shot and shell, all of a heavy description. The total number of killed and wounded during the siege amounted to 1341, so that nearly 200 shot and shell were fired for every man struck. Of the 1341 men hit, 870, or nearly two-thirds, were only slightly wounded and recovered. Could the calculation be made of the number of missiles, that is, of the separate fragments into which the shells burst, the proportion would probably be nearer 1000 missiles for every man struck.[1]

The proportion of hits tos hots fired in bombardments, when suitable protection is provided by engineering skill, appears to be extremely small even at the present day. Lieut.-Colonel Prevost of the French Engineers has stated that during the war of 1870–71, at the bombardment of Mézières, which lasted 38 days, and where there was a population of 65,000 persons, the number of projectiles fired was 193,000, while the number of killed was 300, and of wounded 800; that at the bombardment of Bitche, lasting 14 days, the population being at first 2400, but subsequently 640, from 20,000 to 25,000 projectiles were fired, while the number of killed was 8, and of wounded 7; at Phalsburg, with a population of 2000, from 8000 to 9000 projectiles were fired, killing 7 and wounding 15 persons; at Verdun, the population being 9000 persons, 33,000 projectiles were fired, killing 7 and wounding 22; at Thionville, with a population of 4000 in the place, the bombardment lasting 53 hours, and from 25,000 to 30,000 projectiles being fired, only 2 were killed; while at Longwy, with 200 persons in it, more than 30,000 projectiles were fired, yet no one was either killed or even wounded.[2]

In mixed warfare, too, the number of hits often appears remarkably small in proportion to the number of projectiles fired. Dr. Chenu states, in his history of the Crimean campaign, that the number of projectiles consumed, while it lasted, was 89,595,363. He obtained his information on this subject from the artillery and engineer reports of the different nations engaged in the war. This number includes all kinds of projectiles, great and small. He has also shown that the numbers of killed and wounded in action among the troops of the five armies engaged, Russian, French, English, Piedmontese, and Turks, including in his calculations all the engagements in the open field as well as the siege operations,

amounted to 175,057. After deducting from these latter figures the numbers killed and wounded by cutting and stabbing weapons, by explosions of powder in magazines and mines, and by other causes, and taking into account the number of separate missiles in certain composite projectiles, such as grape-shot, he has come to the conclusion that about 1000 projectiles, great or small, were fired for every man placed *hors de combat*, including both killed and wounded.

According to the report of General Rosencranz, of the United States, on the battle of Murfreesborough, it required 27 gunshot and 155 musket-balls to hit one man on that occasion. It has been a common observation among military men, with regard to the Franco-German war of 1870–71, that a ton of iron was expended for every man killed. This has been a mere fashion of speech or verbal expression without any definite basis; but it sufficiently shows the prevailing notion regarding the smallness of the number of effective hits when compared with the amount of shot and shell fired. At the time that the war was in progress, the enormous fire of artillery on both sides, and the destructive nature of the shell projectiles employed, were the theme of constant observation; yet the 5th section of Fischer's statistics shows that in the Prussian and North German armies only 48 officers and 647 men were killed, and 276 officers and 4113 men wounded, by shell fragments. The loss must have been so out of proportion to the amount of iron discharged as to have seemed to warrant the popular saying just now mentioned.

General conclusion on the subject.—The probable truth is, as mentioned in the beginning of the chapter, that if the numerical force of the whole army engaged in a given war be taken as the basis of calculation, and the total number of projectiles discharged, and of casualties produced, be then compared together, the ratio of casualties in the army to shots fired will not be found to have been much augmented by the improvements effected in modern weapons; but if similar comparisons be instituted with regard to special sections of the army—particular corps or detached bodies of troops which have happened to be brought into close collision in the open field, or to have been subjected to a concentrated fire —the effect of the increased penetrative power of the new projectiles will then be made manifest by a far greater proportion of casualties to the number of shots fired than has been previously experienced under corresponding circumstances.

CHAPTER II

RATIO OF WOUNDS TO PARTICULAR PROJECTILES

There are no statistics which can be accepted as strictly accurate, so far as I am aware, as to the total number of injuries inflicted by the several kinds of projectiles employed during any war, or in any particular battle fought in the open field. The kinds of projectiles by which the injuries inflicted on those who have been killed outright on a field of action has never been ascertained with sufficient attention for the supply of this information; and in the instances mentioned in the previous chapter, in which the number of projectiles fired and the number of deaths resulting from them have been placed on record, it has rarely happened that a statement has been made of the kinds of shot by which the deaths have been caused. In the siege operations which have been mentioned, the projectiles causing fatal wounds would be almost exclusively the heavier kinds of shell and shot; but in the other instances, in which projectiles of all kinds were employed, the facts necessary for distinguishing between them with regard to their different effects have not been collected.

Relative number of wounds by gunshot.—The mass of metal contained in a solid shot, whether discharged from a field gun or gun of position, and the immense force by which it used to be propelled, might at first lead to a supposition that such a shot, when employed, would occupy the first rank among projectiles as to destructive effects. It might be imagined that whole ranks of men, one after another, for long distances, would be mowed down by it while it remained armed with its average amount of speed. This does not appear to have been the case, however, during the period when solid shot were in general use with big guns.

According to the account of Buonaparte, the French army expended 220,000 cannon-balls during the battles fought from the 16th to the 19th of October 1813 at and near Leipsic. The number of musket-shots and other projectiles has not been recorded. The numbers of the allies who were killed and wounded throughout these engagements was 59,000 at the outside. The largest part of this number were certainly, as usual in mixed engagements, wounded by the fire-arms of the infantry; but if no other projectiles but cannon-balls had been used during these battles, the numbers mentioned would show that only one man was struck for nearly every four (3·7) gun projectiles fired.

Whether it was from their mode of flight, the ready view of their approach, from their size, or their tendency to bound to great distances on striking the ground, the physical consequences,

regarded numerically, which resulted from the use of spherical gunshot, were by no means commensurate with the moral effects produced by their discharge. If such a shot came into collision with a soldier, the stroke was fatal to life or limb; but the number of similarly fatal injuries, and of others of less gravity, that would be produced by the bursting of a shell, or by a single discharge of canister or grape among a body of troops, under circumstances equally favourable to the several sorts of projectiles named, would be numerically far greater.

Wounds from different projectiles under hospital treatment.—Although there are no reliable records of the relative proportions of injuries inflicted in the field by particular projectiles, the numbers of wounds by different kinds of shot admitted under hospital treatment have been recorded on various occasions with tolerable exactness. How far the improvements, on the one hand, in guns and their explosives—in the construction of shells, their range, multiplied fragmentation and force—and, on the other hand, the changes in rifles, their greater precision, the increased energy, and rapidity of fire of their projectiles, may hereafter affect the relative numbers of wounds inflicted by large and small missiles, can only be known with any degree of certainty after trial in actual war. Hitherto statistics have shown that, so far as engagements in the open field have been concerned, the number of wounds by the smaller kinds of projectiles have far outnumbered those made by the larger and heavier kinds.

Experience of the Crimean war.—Out of 1657 British troops admitted into hospital for gunshot wounds after the assault on the Great Redan at Sebastopol, on September the 8th, 1855, 1003 had been struck by rifle bullets, and 654 by shell fragments, grape, and gunshot.[3] These figures give a percentage of 60·53 by rifle bullets, and 39·47 by all other kinds of projectiles. Of the two divisions actually engaged in the assault, the numbers were—916 wounded by rifle bullets, or 63·17 per cent.; 534 wounded by grape, round shot, and shell, or 36·82 per cent.

Out of 34,306 wounds admitted into the French ambulances and hospitals during the Crimean war, all of which are tabulated by Dr. Chenu according to the bodily regions wounded, it appears that 13,876 were caused by small-arm bullets, 694 by gunshot, 11,423 by grape-shot and shell, and 7495 by explosions of mines, magazines, and other such sources of injury. The remainder were wounds from cutting or stabbing weapons. It results from this statement that the wounds by bullets averaged 53·4 per cent.; while the wounds from grape, gunshot, and shell, all these large missiles being taken together, amounted to 46·6 per cent. The wounds, regarded separately, from gunshot averaged only 2·7 per cent.[4]

Of the war of 1859.—The proportions differed very materially during the Italian campaign of 1859. The discrepancy is

explained by the different nature of the military undertakings in which the troops were employed on the two occasions. During the Crimean war the greater number of the wounds occurred in the siege operations before Sebastopol, and were inflicted among the besiegers either in the trenches or during the assaults, when the projectiles employed by the besieged consisted principally of shells and grape. During the Italian campaign there were no siege operations; all the principal engagements occurred in the open field.

There is no table in Dr. Chenu's Statistical History of the Italian Campaign which shows the kinds of projectiles by which the wounds treated in hospital were inflicted during the whole war; but in the tables of wounds in the separate regions of the body, distinction is made between those which resulted from bullets, gunshot, shell fragments, and grape. The wounds caused by weapons not depending on gunpowder for their action (*armes blanches*), or derived from other sources, are shown in separate columns. Putting together the wounds caused by projectiles, the numbers are respectively 14,484 by bullets, 159 by large projectiles, and 740 by shell fragments and grape, forming a total of 15,383 gunshot wounds presented at the ambulances and hospitals. The wounds by bullets were therefore 94·2 per cent., those by gun projectiles 1·0 per cent., and those by grape and shell fragments 4·8 per cent. of the total number of gunshot wounds inflicted. In both wars, the Crimean war with its prolonged siege of Sebastopol, and the Italian war with its great battles on the open ground, the large preponderance of wounds caused by shot from portable fire-arms, and the small ratio of the wounds caused by gunshot, are noticeable features.

Of the United States civil war.—Among 245,790 shot wounds inflicted during the prolonged war of the rebellion in the United States, the Surgical History records (vol. iii. chap. xii. p. 696) that the nature of the missile was ascertained in 141,961 cases, and that of this number 127,929, or 90·1 per cent., were caused by missiles from small arms, and the remainder by shell fragments and other large projectiles.

Of the war of 1866.—During the war between Prussia and Austria in 1866, with respect to the Austrian wounded, the relative numbers of wounds by small and large missiles were almost precisely the same as those tabulated in the United States war, viz., 90 per cent. by bullets, and 10 per cent. by gunshot and shell. Among the Prussians the numbers were rather different, viz., 84 per cent. by bullets, and 16 per cent. by large projectiles. The use of the Prussian breech-loading rifles against the muzzle-loaders of the Austrian army, and the more powerful armament in artillery of the Austrians, probably explain these discrepancies.

Of the Franco-German war.—During the Franco-German war of 1870–71 the *boulet*, or solid gunshot, disappeared from the

French statistical returns of battles in the open field. There is only one table in Dr. Chenu's statistics of this campaign which particularises the projectiles or weapons by which the wounds were caused. This is a table, furnished by Dr. De Melun, of 551 wounded received from Gravelotte, and treated at the ambulance established in the farm of Mogador. Of the 551 wounds 100 were caused by fragments of shell, 405 by bullets, 34 by sabres, and 12 by lances. Among the 505 gunshot wounds in this instance, the bullet wounds constituted 80·19 per cent., the wounds by shell fragments 19·80 per cent., of the total number. This partial observation shows a larger proportion of wounds from shell fragments than the general experience among the Germans. According to Fischer's tables, out of every 100 officers and soldiers of the Prussian and North German armies hit by projectiles, 91 were struck by rifle-shot, and 9 only by shell splinters.[5]

As the proportion of field guns has been largely increased of late years in most armies, and the wounding properties of shells immensely multiplied, it seems probable that the proportion of shell wounds to rifle-shot wounds may be much increased in future wars; but in this and many other matters of a like kind the events of actual warfare may overthrow all anticipations.

CHAPTER III

NUMBERS AND RATIOS OF CASUALTIES, AND PROPORTIONS OF KILLED TO WOUNDED, IN VARIOUS BATTLES

General remarks.—The usual proportion of casualties among troops engaged in war, the ratios of killed to wounded, and the relative proportions of particular wounds, are subjects which involve many matters of interest, not merely to officers in immediate command of armies, but also to those upon whom the duty devolves of providing and maintaining reserves to fill up the gaps occasioned by the service in which the troops are engaged. But it is also a subject which has to be considered by those who have charge of the medical concerns of armies; for the usual proportions of such casualties and their kinds must be studied when the amount of hospital stores, hospital transport, and surgical attendance necessary to be provided in the first instance for a campaign has to be calculated, and also when preparations have to be made for the reception and care of the wounded that may result from an impending general engagement with the enemy.

By tabulating the ratios of casualties in some of the great battles of the last century side by side with those of later dates, an opportunity is afforded of studying some of the effects of the

changes which have taken place in military fire-arms; but owing to the defective nature of some of the records from which the figures have been taken, the discrepancies in the statements of general officers in the opposing forces, and the doubtful meaning attached to some of the expressions used by them, the tables in some instances can only be regarded as approximately correct.

Explanation of different statements regarding losses in war.—There are many sources of fallacy in the statements made respecting the numbers of casualties in particular battles. Few inquiries are more difficult than those for finding the proper value of the figures in the numerical lists of casualties furnished by military commanders and historians, not merely as to former, but occasionally even in regard to recent wars.

The truth of this remark forces itself into notice in many ways. In the first place, in examining military records, it is found that the stated numbers of casualties in particular battles vary very greatly according as the authorities of the countries opposed to one another are consulted on the subject. Serious discrepancies are met with both as to the strength of the troops engaged, and also as to the numbers of casualties. It is easy to discern, in some instances, on the part of the rulers on the vanquished side, efforts to curtail the extent of the calamity which has happened to their country; equally easy, occasionally, to observe attempts on the part of the victors to exaggerate the injury they have done to their opponents. But not only are conflicting statements with respect to the losses incurred published in the countries which have been opposed to each other in war, but they are found in the records of one and the same country. Without imputing dishonest or interested motives to account for these discrepancies, several fertile sources of contradiction in the mere manner by which the accounts of alleged facts may have been obtained occur to one's mind. It may be useful to point out a few possible causes of such conflicting statements.

In some instances, the number stated to have been killed in a particular action represents only those actually killed during the fight and left dead on the field; in other instances, those who have died within a few days subsequently from the effects of their wounds are included among the killed. The discrepancies from this source become multiplied according to the number of days which may have elapsed before the 'returns of deaths' have been collected and totalled up.

Errors as to the numbers *wounded* in battles arise in a similar way. The delay of a single day in the time of collecting the returns of casualties will often cause an important difference in the number returned as wounded on a given occasion.[6]

There is generally a praiseworthy desire to send off returns of casualties as early as possible after an engagement, in order to

satisfy the anxiety for intelligence among the countrymen, as well as the relatives and friends, of the officers and men of which an army is composed. It is almost impossible, under the circumstances in which troops are usually placed at this time, to avoid numerous errors in making up the lists out of which the general returns of casualties are framed. In the columns of 'killed' are sometimes placed absentees who are either lying wounded in some of the temporary field hospitals or who have strayed from their respective corps; in the columns of 'missing' or 'disparus' are placed some who, as afterwards proved, should have been accounted for in the columns of killed or wounded. Men with slight injuries appear in the first returns as wounded, but, joining their ranks for duty without entering a hospital, appear the next day in the lists of effective soldiers; and then, in order to balance the respective figures of 'strength' and 'losses,' they cease to be counted among the number of wounded. Such are a few among many causes of differences in the sums-total of casualties, even after comparatively slight engagements, between the numerical returns rendered shortly after the actions have transpired and those furnished at later periods. Sometimes the early returns, sometimes the later, are quoted by writers, and hence some of the disparities which are met with in historical records on the subject. In great battles, especially in battles renewed for several successive days, the difficulties of procuring correct returns of the casualties and of their nature are increased a thousand-fold. As regards the forces which are completely beaten in a conflict, and driven away, the difficulties in the way of obtaining exact accounts of the casualties may indeed be said to be almost insuperable.

The term 'losses,' too, is employed with such various significations that it is frequently difficult to determine what its meaning is intended to be in the accounts given of early battles by writers. Sometimes the expression seems to be used to indicate the number of casualties of all kinds, including killed, wounded, prisoners, and missing, that is, the loss in the effective strength from all causes; sometimes it includes only the killed and wounded; sometimes the 'losses' refer to no others but the deaths, the wounded being spoken of separately.

It is generally thought, with regard to the numerical losses attributed to Continental battles of the last, and early part of the present century, that large numbers of soldiers who died from disease induced by various causes during the movements of the armies, as well before as after the particular battles referred to, were accounted for by being included in the losses of the battles themselves.[7] The national and military feelings were less hurt by a large number of casualties having occurred in conflict with the enemy, than they would have been had the losses resulted from sickness brought on by fatigue and exposure.

Moreover, military and medical statistics were neither so strictly kept in former days, nor were they so capable of being analysed, as they have been of late years.

Proportion of casualties to troops engaged.—But whatever may be the difficulties in determining the number wounded in particular battles, the difficulty of ascertaining the ratios of casualties to those *actually engaged* in the fighting is far greater. Yet this is the important point to be informed upon when trying to estimate the average amount of surgical dressings and appliances, as well as transport, required for the wounded of a stated force. The number of wounded that may result from an action in which only half or one-fourth of the army has been engaged as combatants, should be set down as the proportion of wounded to the strength, whatever it may be, of that half or fourth section of the army; not to that of the whole army, of which a part, though exerting, perhaps, an important military influence as a force in reserve, cannot fairly be reckoned in a computation of the ratio of wounds to combatants, as if it had actively participated in the fighting. Two divisions of the British army were not brought into action on the occasion of the first pitched battle in the Crimea, that of the Alma; in calculating the proportion of casualties to fighting men, the strength of these two divisions should clearly be separated from that of the forces which were actively occupied in the battle. It was estimated by General Von Moltke that 92,000 men who formed part of the Prussian army in 1866 at the battle of Königgrätz never fired a shot; these, therefore, ought to be excluded from the number of combatants when estimating the proportion of hits to troops on that occasion. If they had taken an active part in the fighting, it is to be presumed that the number of casualties would have been proportionately increased.

Statistics show that the general proportion of casualties in war has not increased since the introduction of the improved weapons of recent years. A paper appeared in the journal of the United Service Institution for 1862, in which the writer was led to question the superiority of the rifle over the smooth-bore musket as a weapon of destruction in armies. In favour of this view the following were given as the ratios of casualties in particular battles:—'During the late Italian war both sides had rifles, the French had also rifled cannon. How was it that the mortality, the carnage, instead of being greater, was actually much less than in any previous wars with the smooth-bore of old?

'At Austerlitz the loss of the French was 14 per cent. of their army, that of the Russians 30, that of the Austrians 44.

'At Wagram the French lost 13 per cent., the Austrians 14.

'At the Moskowa the French loss was 37 per cent., the Russian 44.

'At Bautzen the French lost 13 per cent., the Russians and Prussians 14.

'At Waterloo there fell of the French 36 per cent., of the Allies 31.

'And now at Magenta, on the 4th of June 1859, we find that the French lost 7 per cent., and the Austrians 8 per cent.

'And at Solferino the Franco-Sardinian army lost 10 per cent., the Austrian 8 per cent.' [8]

A statement to the same effect has been put forth in another form. It has been said that the losses of the victors in the following great battles were—at Waterloo, one-fourth; at Borodino, a third; at Talavera, an eighth; at Marengo, a fourth; at Inkerman, before rifle guns and breech-loaders were in use, a third; while at Magenta and Solferino the losses were only one-eleventh, and at Königgrätz, one-twenty-third.[9] The facts quoted in these statistics are incontrovertible, but the deductions which have sometimes been drawn from them are, to say the least, calculated to mislead. Most of the statistical figures show the proportions of casualties (the term 'losses' in most of the foregoing quotations evidently comprehends killed, wounded, and missing) not to the troops against whom the fire-arms employed were actually used, but to the entire army under command—not only to the men actually on the battle-field, but also to men detached, sick, and held in reserve; in short, to the whole force of which the troops engaged formed merely a part. The percentages, too, are in certain instances materially influenced by the loss of men unwounded but taken prisoners, these being included in the column of missing.

The number of troops actually brought into the field in some important battles has been comparatively small, so that they have all been actually engaged in the conflict; perhaps, too, for many consecutive hours. The Adjutant-General's 'Morning State' at Waterloo, on the 18th of June 1815, showed the strength of the British army to be 49,309. But twelve battalions of the army were detached at Courtrai, Brussels, Braine le Comte, Antwerp, and at other places; and a certain number were sick in hospital; while others were prisoners or missing. These being deducted, the numbers present on the field of Waterloo (officers, non-commissioned officers, and rank and file included) were reduced to 36,240. These 36,000 troops were exposed to fire from day-break to night, and a large proportion of them were in repeated close conflict with the enemy. Hence the large ratio of casualties among them. Large as it was, however, it would almost amount to an absurdity to suppose that, had they been subjected, under similar conditions, to shot from the improved rifles and rifled guns of the present time for the same number of hours, instead of from the smooth-bore muskets and guns then in use, the

number of killed and wounded among them would not have been vastly increased. Yet the inference which might be drawn from some of the remarks above quoted is that the carnage, instead of being greater, would actually have been less. At the present day the facilities of rapidly concentrating troops and their matériel are immensely increased. Such armies as were opposed to each other at Solferino and Königgrätz present numbers so enormous —in the former instance 298,358, in the latter 427,100 men under arms being said to have been brought together—that it becomes impossible for all the troops to be engaged in the battle. The firing, especially of the infantry, being restricted to almost directly opposite fronts, the bodies of troops acting as supports or reserves in such vast armies are almost necessarily excluded from active interference as combatants—as 'troops actually engaged.' But in estimating the comparative losses, as they have been in the quotations cited above, the strength of the whole army, including its reserves, appears to have been taken as that of the fighting strength, while the casualties, which have really occurred only in the particular bodies of troops brought to close quarters in the combat, have been distributed amongst the whole of the force, whether engaged or absent. No deductions as to the qualities of the weapons employed on the different occasions referred to can be drawn from such calculations. As well might it be argued that clubs, swords, and lances were more destructive than fire-arms, because, as is well known to have been the case, the usual proportion of *injuries* to the number of combatants was greater before the application of gunpowder to weapons of offence than it has been since; the real explanation being that in the battles of early times, when hotly contested, each individual after a time came to be engaged in a hand-to-hand encounter in which one or other was sure to receive some sort of injury, so that the number of men wounded in a battle must often have closely corresponded with the number of fighting men taken into the field. It need hardly be remarked that a considerable proportion of such injuries would be of a comparatively harmless character. When portable fire-arms were introduced, these personal encounters in great measure ceased, and as they and the larger kinds of guns gradually had their range and power increased, the distances apart maintained by combatants in the open field were gradually extended also. While the old 'Brown Bess' was the fire-arm of our infantry, it would have been almost futile to have used it against an enemy that was more than a hundred yards or so off, while, on the other hand, cavalry could charge and inflict wounds upon infantry soldiers with comparative impunity. Men in those days fired against each other at comparatively close quarters, and the wounds, in proportion to shots fired, might be expected to be very numerous. On rifled fire-arms being used, the distances taken by combatants,

whenever practicable, became greatly increased, and with the rifles of the present day the distances apart of the hostile troops will, as a general rule, have to be far greater, and the extent of ground occupied much ampler. There may be a greater proportion of misses to shots fired under these circumstances; but whenever the conditions of the contest are such that the shots discharged, whether from guns or rifles, can be used against troops with effect, it must necessarily happen that the superior qualities of the present weapons will cause them to produce an increase in the proportionate number of wounds among them.

It is evident that, besides the nature of the weapons used, the particular circumstances of battles, whether engagements in the open field, assaults, or others, the distances apart of the hostile troops, their tenacity, the numbers actually brought into collision, the duration of the fighting, the nature of the casualties comprehended under the general term 'losses,' must all separately be considered before one battle can be properly compared with another, so far as concerns the wounding effects of the weapons employed by the combatants. The ratios above quoted serve sufficiently to show that when all the troops, not only those actually brought into action, but also those acting as supports and reserves or otherwise on the strength of an army, are included, modern tactics, and the present facilities for bringing large masses of men together for military purposes, cause the chance of a wound or other casualty happening to any one of the units composing that army to be considerably less than it was formerly; but, notwithstanding this general deduction, numberless facts, which it would be out of place now to bring forward, have proved, as regards the particular troops which are opposed to each other in actual fighting, that the number of severe wounds inflicted within corresponding periods of time is far greater than they ever were before the introduction of rifles and breech-loaders, and there is no ground for supposing that this general statement will not hold good as regards the future, although more recoveries may ensue among them under improved methods of treatment.

The following table has been put together to show the percentages of the various descriptions of casualties in certain great battles and wars of the last and present century.[10] It shows not merely the percentages of the general losses, but, as far as procurable, those of the killed, wounded, and missing respectively. Great pains have been taken to obtain the numbers on which the calculations are based from the most impartial sources, and, with regard to later battles, from the most reliable official returns. References to the authorities whence the strength and numbers of casualties named in the table have been obtained will be found in the Appendix. Where blanks occur, the necessary information could not be obtained from any of the accounts examined.

Table showing the Proportions of Killed, Wounded, and Missing in various Battles.

Battles.	Nation.	Strength.	Numerical Losses. Killed.	Numerical Losses. Wounded.	Numerical Losses. Missing.	Numerical Losses. Total.	Percentage of Killed.	Percentage of Wounded.	Percentage of Missing.	Percentage of Total Loss.	Ratio of Killed to Wounded.
Blenheim, August 13, 1704	British and Allies	56,000	5,000	8,000	0	13,000	9	14	0	23	1 to 1·6
	Gallo-Bavarians	60,000	12,000	14,000	14,000	40,000	20	23	23	66	1 to 1·1
Ramillies, May 23, 1706	British and Allies	60,000	1,066	2,867	0	3,933	2	5	0	7	1 to 2·6
	Gallo-Bavarians	62,000	2,000	5,000	6,000	13,000	3	8	9	20	1 to 2·5
Belgrade, August 17, 1717	Austrians	40,000	8,000		...	8,000	20		...	20	
	Turks	140,000	28,000		...	28,000	20		...	20	
Kunnersdorf, August 12, 1759	Prussians	40,000	8,000	15,000	3,000	26,900	20	38	7·5	65	1 to 1·9
	Russians and Austrians										
Austerlitz,[11] December 2, 1805	French	70,000	12,000		0	12,000	17		0	17	
	Austrians and Russians	84,000	26,000			26,000	31			31	
Maida,[12] July 4, 1806	French	7,500	700	3,300	0	4,000	9·33	44·00	0	53·33	1 to 4·7
	English	5,000	45	284	0	329	0·9	5·68	0	6·58	1 to 6·3
Wagram, July 6, 1809	Austrians	90,000	24,000		1,000	25,000	27		1·1	28	
	French	140,000	25,000		7,000	32,000	17		5	22	
Talavera,[13] July 28, 1809	British	22,000	875	3,913	652	5,422	3·89	17·78	2·96	24·65	1 to 4·5
Albuera,[14] May 16, 1811	British	7,530	988	3,002	0	3,990	13·12	39·86	0	52·98	1 to 3·0
Badajos,[15] March 17 to April 6, 1812 (whole siege)	British and Portuguese	21,784	1,035	3,787	0	4,822	4·75	17·38	0	22·13	1 to 3·6
Badajos,[16] April 6, 1812 (assault)	British	10,200	651	2,349	22	3,022	6·40	23·03	·21	29·62	1 to 3·6
Salamanca,[17] July 12, 1812	British	25,381	336	2,400	74	2,810	1·32	9·46	·29	11·07	1 to 7·1
	Portuguese	17,518	287	1,436	18	1,741	1·64	8·20	·10	9·94	1 to 5·0
Moskowa, or Borodino, September 12, 1812	Russians	125,000	15,000	35,000	1,000	51,000	12	28	·8	40	1 to 2·3
	French	120,000	9,000	13,000	1,000	23,000	8	11	·8	19	1 to 1·4
Bautzen,[18] May 20, 1813	Prussians and Russians	110,000	7,500	16,000	0	23,500	7	14	0	21	1 to 2·1
	French	150,000	8,800	18,000	0	26,800	6	12	0	18	1 to 2·2
Vittoria,[19] June 21, 1813	British and Portuguese	60,486	4,626			4,626	...	...	...	7·65	
	British	35,129	501	2,807	0	3,308	1·42	7·99	0	9·41	1 to 5·6

Leipzig,[20] October 16 to 19, 1813	Allies	300,000	47,000		0	47,000	16		0	16	
	French	171,000	15,000	30,000	15,000	60,000	9	18	9	36	1 to 2·0
Toulouse,[21] April 10, 1814	British and Allies	53,417	595	4,046	0	4,641	1·11	7·57	0	8·68	1 to 6·8
Waterloo,[22] June 18, 1815	British	36,240	1,759	5,892	807	8,458	4·85	16·25	2·19	23·31	1 to 3·3
	Hanoverians	11,220	288	1,124	816	2,228	2·56	10·01	7·27	19·85	1 to 3·9
	German Legion	5,824	306	866	209	1,381	5·25	14·86	3·58	23·71	1 to 2·8
Alma,[23] September 20, 1854	English	21,481	362	1,621	0	1,983	1·68	7·54	0	9·32	1 to 4·4
	French	30,328	144	1,197	0	1,341	0·46	3·94	0	4·40	1 to 8·3
	Russians	60,000	1,807	2,821	1,008	5,636	3·01	4·70	1·68	9·39	1 to 1·5
Inkerman,[24] November 5, 1854	English	14,000	529	2,286	0	2,815	3·77	16·32	0	20·10	1 to 4·3
	French	41,019	229	1,551	70	1,850	0·55	3·78	0·17	4·51	1 to 6·7
	Russians	55,000	6,062	9,406	267	15,735	11·02	17·10	0·48	28·60	1 to 1·5
Crimean war,[25] September 20, 1854, to end of war	English	97,864	2,755	12,094	0	14,849	2·81	12·35	0	15·17	1 to 4·4
	French	(?)	8,250	39,868	0	48,118	...	...	...	...	1 to 4·8
Montebello,[26] May 20, 1859	French and Sardinians	8,227	105	549	69	723	1·28	6·67	0·84	8·79	1 to 5·2
Magenta, June 4, 1859	French	48,090	657	3,223	655	4,535	1·37	6·70	1·36	9·43	1 to 4·9
	Austrians	61,640	1,365	4,348	4,500	10,213	2·21	7·05	7·30	16·56	1 to 3·2
Solferino, June 24, 1859	French and Sardinians	135,234	2,313	12,102	2,776	17,191	1·71	8·95	2·05	12·71	1 to 5·2
	Austrians	163,124	2,386	10,634	9,290	22,310	1·46	6·52	5·70	13·68	1 to 4·5
Italian war,[27] of 1859 (whole war)	French	189,690	2,536	19,672	1,128	20,718	1·33	10·37	0·59	12·29	1 to 7·7
	Sardinians	(?)	1,010	4,922	1,268	7,200	...	...	...	...	1 to 4·9
	Austrians	(?)	5,416	26,149	17,306	48,871	...	...	...	...	1 to 4·8
Shiloh,[28] April 6 and 7, 1862	Unionists	63,000	1,735	7,882	3,956	13,573	2·75	12·51	6·27	21·83	1 to 4·5
	Confederates	40,000	1,728	8,012	959	10,699	4·32	20·03	2·39	26·74	1 to 4·6
Antietam,[29] September 17, 1862	Unionists	87,164	2,010	9,416	1,043	12,469	2·30	10·80	1·19	14·30	1 to 4·6
	Confederates	97,445	3,500	16,399	6,000	25,899	3·60	16·82	6·15	26·58	1 to 4·6
Murfreesboro',[30] December 31, 1862, to January 2, 1863	Unionists	43,400	1,533	7,245	2,800	11,578	3·53	16·69	6·45	26·67	1 to 4·7
	Confederates	35,000	9,000		2,000	11,000	25·71		5·71	31·42	
Gettysburg,[31] July 1 to 3, 1863	Unionists	117,350	2,834	13,709	6,643	23,186	2·41	11·68	5·66	19·75	1 to 4·8
	Confederates	68,352	3,500	14,500	13,621	31,621	5·12	21·21	19·92	46·26	1 to 4·1
Chickamauga,[32] September 19 and 20, 1863	Unionists	50,000	1,644	9,262	4,945	15,851	3·28	18·52	9·89	31·70	1 to 5·6
	Confederates	53,000	2,389	13,412	2,003	17,804	4·50	25·30	3·77	33·59	1 to 5·6
Wilderness,[33] May 5 to 7, 1864	Unionists	100,000	2,309	12,185	3,893	18,387	2·30	12·18	3·89	18·38	1 to 5·2
	Confederates	(?)	2,000	6,000	3,400	11,400	...	...	...	...	1 to 3·0
United States war of rebellion,[34] April 1861 to May 1865	Unionists	(?)	59,860	280,040	184,791	524,691	...	...	...	...	1 to 4·7
	Confederates	(?)	51,425	227,871	384,281	663,577	...	...	...	...	1 to 4·4
New Zealand war,[35] January 1, 1863, to February 15, 1866	British	7,930	182	506	0	688	2·29	6·38	0	8·67	1 to 2·8

Table showing the Proportions of ***Killed****, Wounded, and Missing in various Battles*—continued.

Battles.	Nation.	Strength.	Numerical Losses. Killed.	Numerical Losses. Wounded.	Numerical Losses. Missing.	Numerical Losses. Total.	Percentage of Killed.	Percentage of Wounded.	Percentage of Missing.	Percentage of Total Loss.	Ratio of Killed to Wounded.
Prusso-Danish war of 1864[35] (5 months) . . (a)	Prussians . . .	46,000	422	2,021	0	2,443	0·92	4·39	0	5·31	1 to 4·8
,, . . (b)	Prussians . . .	16,000	422	2,021	0	2,443	2·63	12·63	0	15·26	1 to 4·8
,, . . (c)	Danes	12,000	678	1,222	0	1,900	5·65	10·18	0	15·83	1 to 1·8
Königgrätz,[37] July 3, 1866 (a)	Prussians . . .	220,984	1,929	6,948	276	9,153	0·87	3·14	0·12	4·14	1 to 3·6
,, . . (b)	Prussians . . .	129,000	1,929	6,948	276	9,153	1·49	5·38	0·21	7·08	1 to 3·6
,, . . (c)	Austrians and Saxons .	215,028	5,793	17,805	7,836	31,434	2·69	8·28	3·64	14·61	1 to 3·0
,, . . (d)	Austrians and Saxons .	150,000	5,793	17,805	7,836	31,434	3·86	11·87	5·22	20·95	1 to 3·0
Weissenberg,[38] August 4, 1870	Germans . . .	106,928	293	1,082	153	1,528	0·27	1·01	0·15	1·43	1 to 3·7
Saarbrück and Spikeren, August 6, 1870 . .	Germans . . .	119,033	862	3,632	372	4,866	0·72	3·05	0·31	4·08	1 to 4·2
Spikeren (separately), August 6, 1870	Germans . . .	28,000	843	3,656	372	4,871	2·9	12·7	1·32	16·9	1 to 4·3
	French	20,000	320	1,662	2,096	4,078	1·6	8·3	10·48	20·3	1 to 5·2
Woerth, August 6, 1870 .	Germans . . .	167,119	1,628	7,570	1,444	10,642	0·97	4·53	0·86	6·36	1 to 4·7
	Germans . . .	160,000	1,589	7,680	1,373	10,642	0·9	4·8	0·85	6·6	1 to 4·8
	French	46,000	11,000		6,000	17,000	24		13·04	36·9	
Borny, August 14, 1870 .	French	83,000	377	2,641	590	3,608	0·4	3·2	0·71	4·3	1 to 7·0
	Germans . . .	60,000	1,189	3,590	127	4,906	1·9	5·9	0·21	8·1	1 to 3·0
Vionville, August 16, 1870 .	Germans . . .	151,858	3,289	10,282	1,249	14,820	2·16	6·77	0·82	9·75	1 to 3·1
	French	126,170	1,367	10,122	5,472	16,961	1·08	8·00	4·33	13·4	1 to 7·4
Gravelotte, August 18, 1870	Germans . . .	278,131	4,449	15,189	939	20,577	1·60	5·46	0·33	7·39	1 to 3·4
	French	125,000	1,144	6,711	4,420	12,275	0·9	5·37	3·53	8·0	1 to 5·8
Sedan, September 1, 1870 .	Germans . . .	190,239	1,637	6,483	912	9,032	0·86	3·40	0·48	4·74	1 to 3·9
	French	124,000	3,000	14,000	21,000	38,000	2·41	11·3	16·92	30·6	1 to 4·6
Orleans, October 11, 1870 .	Germans . . .	56,553	170	662	87	922	0·30	1·17	0·15	1·62	1 to 3·9
Coulniers, November 9, 1870	Germans . . .	38,951	69	533	621	1,223	0·18	1·37	1·59	3·14	1 to 7·6
Amiens, November 27, 1870	Germans . . .	52,430	181	1,022	31	1,234	0·34	1·95	0·06	2·35	1 to 5·7
Beaune-la-Rolande, November 28, 1870 . . .	Germans . . .	91,405	110	645	118	873	0·12	0·70	0·13	0·95	1 to 5·8
Le Mans, January 10, 1871 .	Germans . . .	123,749	289	895	118	1,302	0·23	0·72	0·09	1·05	1 to 3·1
Lizaine, January 15, 1871 .	Germans . . .	64,735	236	1,078	227	1,541	0·36	1·66	0·35	2·37	1 to 4·6
Franco-German war,[39] July 24, 1870, to April 1, 1871	Whole German army, South German included . .	887,876	17,570	96,189	4,009	117,768	1·97	10·83	0·45	13·26	1 to 5·4

General ratio of killed to wounded in war.—An examination of the foregoing table shows that the ratio of killed to wounded in war has hitherto varied very considerably. The lowest proportion of men killed to the number wounded in action occurred among the French troops at the battle of the Alma, viz., 1 killed to 8·3 wounded; while the highest noted was among the Gallo-Bavarians at Blenheim, where the killed and wounded were in nearly equal proportion. The number killed was nearly as great in proportion to the number wounded among the Russians at both the battles of the Alma and Inkerman. It is difficult to explain the small number of killed relatively to the number of wounded among the French at the Alma. On summing up the ratios of killed and wounded in the whole of the battles and wars noted in the table, the mean ratio of the killed to the wounded will be found to be nearly as 1 to 4. This ratio gives 20 killed and 80 wounded in every 100 casualties; and if we might judge from the experience gained down to the present time, such may be regarded as an approximate average of the proportion of killed to wounded likely to be met with in battles. It is generally surmised that the employment of small-bore bullets will lead to the proportionate numbers of men killed in battle being lessened, and that of the men wounded being increased, so far as regards rifle fire; but even if this surmise should prove to be correct, when the uncertainty which prevails regarding the probable effects of the new artillery fire is considered, it seems evident that the general ratio of killed to wounded among troops in wars of the future cannot now be forecast with any approach to accuracy.

CHAPTER IV

RELATIVE TARGET AREAS OF THE PRINCIPAL DIVISIONS OF THE HUMAN BODY

Before examining the records of particular battles or wars with a view to determine the proportionate number of wounds inflicted in different parts of the body, I have thought it might be of some interest to consider the relative areas of the several regions of the body exposed to be hit by projectiles in the case of a man presenting his full front to an enemy. It is hardly necessary to remark that the same proportions are not likely to be maintained by any individual soldier, nor by troops advancing in a body, in actual warfare. When men are marching in close order, their movements are constantly altering the relations of the different parts of their bodies and limbs; some of the troops are more or less covered by others in front; if exposed to fire, the direction

in which the bullets or fragments of shell fall on them is continually varying as the distance from the enemy varies; and when soldiers are acting independently, the positions assumed by them are unlimited, and all of them such as materially to change the relative areas of the different parts of the body as they exist in the stationary upright posture. It is only as a basis for comparison that information on the respective areas of the different parts of the body can be regarded as possessing any value.

Target area of the whole front of a soldier.—I am not aware that any perfectly reliable calculations on this head have been made, and much difficulty is met with in attempting to obtain the information from actually measuring the surface of the body itself. M. Quetelet has put down the whole outer surface of a man measuring a small fraction over 5 feet 8 inches in height, and weighing about 168 lbs., as 2549·75 square inches; and Valentin, measuring his own body, his height being 5 feet 3 inches, and his weight nearly 120 lbs., found its whole superficial area to be 2325 square inches. The target area of the full front of a man would of course be considerably less than half the total surface area, as the lateral aspects of the body would not be exposed any more than the back under the circumstances named. According to the observations noted in the last table of this chapter, it appears that the target area presented by the full front of a well-proportioned man 6 feet in height, is a little over 1000 square inches.

Target areas of particular regions of the body.—What is of most interest, however, to military surgeons is the amount of target surface presented by particular parts of the body, or, in other words, the relative exposure of its different regions to be struck by projectiles in battle, supposing the missiles to be equally distributed. It is obvious that if one region presents double the target area of another, the expectation will be, all other things being equal, that, out of a given number of wounds, there will be twice as many in the former as there will be in the latter region.

It appeared to me that this information might approximately be obtained if a careful measurement were made of certain delineations of the human frame of acknowledged excellence. I therefore selected a few for the purpose, and it was interesting to observe how closely their relative measurements and areal percentages agreed with each other.

Relative regional areas in drawings by Albinus.—There are two classical drawings of the human frame by Albinus[40]—better known in this country, perhaps, through the copies of them by Andrew Bell—the one exhibiting the external form and muscular development of the full front; the other, of the side aspect of the body. These drawings have been accepted as standards of just proportions and anatomical correctness. The relative amounts of superficial area presented by the principal divisions of these draw-

ings were measured; both of the reduced drawings being divided into squares of one-hundredth of a square inch in dimensions.

The following was the result obtained with the figure presenting a full front:—

Figure, Full Front.

Part of Body.	Space Occupied.	
	Absolutely in $\frac{1}{100}$ths of Square Inches.	Relatively in Percentages of the Whole Surface.
Head and Face . . .	167	5·2 per cent.
Neck	73	2·3 ,,
Trunk (Chest and Abdomen) .	902	28·1 ,,
Upper Extremities . . .	690	21·5 ,,
Lower Extremities . . .	1378	42·9 ,,
Total	Square Inches. 32·10	100·0

The measurements of the side view of the body, made by the same method, gave remarkably similar results. They were as follows:—

Figure, Side View.

Part of Body.	Space Occupied.	
	Absolutely in $\frac{1}{100}$ths of Square Inches.	Relatively in Percentages of the Whole Surface.
Head and Face . . .	156	5·0 per cent.
Neck	90	2·9 ,,
Trunk	850	27·5 ,,
Upper Extremities . . .	670	21·7 ,,
Lower Extremities . . .	1324	42·9 ,,
Total	Square Inches. 30·90	100·0

The mean of both figures gives the following results:—

Part of Body.	Relation of Area to that of the Whole Surface.
Head and Face	5·1
Neck	2·6
Trunk	27·8
Upper Extremities	21·6
Lower Extremities	42·9
Total	100·0

Relative regional areas in Liharzik's figures.—A similar calculation was made by examining on the same plan the drawing of the external proportions of the human frame, front view, at the 300th month, in Dr. Liharzik's work on 'The Law of Increase in the Structure of Man.' This observation gave slightly different proportions. They were as follows:—

Part of Body.	Relation of Area to that of the Whole Surface.
Head and Face	7·0
Neck	3·6
Trunk	30·3
Upper Extremities	19·7
Lower Extremities	39·4
Total	100·0

The variations appear to be due partly to an altered position of the head and neck, and partly to differences in the outlines of the figures. The relations of the two extremities in all the instances is alike; that is, the area of the lower extremity is double that of the upper extremity in Liharzik's figure, as it was found to be on measuring the figures drawn by Albinus.

Regional areas of the Pythian Apollo and Farnesian Hercules.—The statue of the Pythian Apollo, measured in a similar manner, notwithstanding that the attitude differed from those in the preceding drawings, gave closely approximate results. The following percentages were calculated from a drawing of the front aspect of the Apollo, in Andran's plates of the proportions of the human body, the detailed measurements of which were taken carefully from the statue itself.[41] In this instance the head is turned so as to present the face sideways, and one arm is fully extended.

Part of Body.	Relation of Area to that of the Whole Surface.
Head and Face	6·2
Neck	2·4
Trunk	30·3
Upper Extremities	19·9
Lower Extremities	41·2
Total	100·0

The front view of the statue of the Farnesian Hercules, in the same work, similarly measured, gave the following proportional areal contents:—

Part of Body.	Relation of Area to that of the Whole Surface.
Head and Face	5·58
Neck	2·28
Trunk	28·64
Upper Extremities	22·00
Lower Extremities	41·49
Total	99·99

Relative regional areas in one of Marshall's physiological diagrams.—The late Surgeon Moffitt, when Instructor of the Army Hospital Corps, measured for me, in a similar manner, the target area presented by one of the large figures, six feet in height, of Marshall's 'Physiological Diagrams.' These life-size and well-proportioned drawings were used by him in instructing the men under his charge. The following were the results of Dr. Moffitt's measurements :—

Part of Body.	Target Area in Square Inches.	Relation of Area to that of Whole Body.
Head and Face	56·25	5·60
Neck	22·50	2·24
Trunk	276·00	27·53
Upper Extremities . . .	226·00	22 53
Lower Extremities . . .	422·00	42·10
Total	1002·75	100·00

Mean of the foregoing measurements.—The percentages of the areas of the five principal divisions of the body, shown in this last table, closely correspond with those derived from taking the mean of the measurements of the two anatomical figures of Albinus. On taking the mean of the measurements of the five figures before named, viz., those of Albinus, Liharzik, the Apollo and Hercules, and that by Marshall, the following is the result :—

Region of Body.	Percentage of the Whole Target Area of the Body.
Head and Face	5·89
Neck	2·62
Trunk	28·91
Upper Extremities	21·14
Lower Extremities	41·41

These numbers, therefore, may fairly be taken as a standard of the relative amounts of target area which would be presented by the different bodily regions of a soldier in case he presented his full front to an enemy in battle, under circumstances of equal exposure to shot, and will sufficiently serve for purposes of comparison with the distribution of wounds which are likely to be met with in actual war under different conditions of exposure.

CHAPTER V

RATIOS OF WOUNDS IN PARTICULAR BODILY REGIONS IN WARFARE

Variations in the regional distribution of wounds in warfare.—As previously stated, it is not to be expected that the regional proportions of wounds resulting from war will correspond numerically with the percentages of areal exposure of the body mentioned in the preceding chapter. The numbers of wounds inflicted in battle in particular regions of the body are caused to vary by a great number of circumstances. The nature of the military operations—whether they consist of sieges and assaults, of battles on open plains, over rugged and broken ground, in a mountainous country, in forest or bush—will always exert an important influence in this regard. In siege operations the parapets of the trenches screen the lower parts of the body, and the number of wounds in these situations will usually be proportionably lessened; in engagements in the open field, on the other hand, it may be expected that the wounds inflicted will be distributed in more even numbers over both the upper and the lower parts of the body.

If firing should commence when infantry troops are very far apart from each other, the bullets fall at the end of a very long trajectory, and the upper parts of the body are more exposed to be struck by them. If the troops are within point-blank range, the shot may be expected to be distributed evenly over the body, for the line of fire under such circumstances will almost certainly be a directly forward one, notwithstanding aim in some particular direction may have been ordered.

The more level the surface of the ground on which the opposing troops are placed, the nearer may be expected to be the approach to the average regional distribution named in the preceding chapter; the more broken and uneven, the more that average will be disturbed. Variations in hardness and softness of the ground affect the proportion. When the ground is rocky or frozen, many bullets, on striking it, glance upwards with considerable force. The legs and thighs of soldiers are not unfrequently wounded by projectiles which have rebounded from hard ground or stones, and the number of wounds in the lower extremities thus becomes increased. When the ground is soft, as when the troops are marching over ploughed fields, this source of additional wounds is in great measure avoided.

On the other hand, the lower limbs are not unfrequently protected from the effects of fire, both direct and indirect, by objects in front of them, and by the practice of soldiers to take advantage

of any cover they can obtain—in ditches, holes, behind trees, walls, and other obstructions—whenever circumstances admit of their doing so. The higher parts of the body can rarely have the advantage of any such protection. The upper extremities, and the hands especially, are exposed to injury in action. They are necessarily left uncovered in carrying and handling the fire-arms; and are constantly advanced in aiming and firing, as well as in a variety of work requiring manual exertion and dexterity. As a consequence of this constant exposure, although the target area of the upper extremities is so much less than that of the lower extremities, quite as many, and often more, wounds of the arms and hands will be met with among hospital admissions than wounds of the lower limbs.

Wounds of the hand in warfare.—The disproportionate number of wounds of the hands and fingers has frequently attracted attention in campaigns. One reason given for their frequency on the occasion when the celebrated inquiry by order of the first Napoleon was instituted, under the presidency of Baron Larrey, after the battles of Bautzen and Wurschen,[42] was the nature of the ground over which the French troops fought. The infantry charges were chiefly made up the slopes of hills. The soldiers had their hands raised on their firelocks in front of them as they ascended, aiming at the enemy on the summits above, and thus their hands were frequently struck because they were the parts most advanced, and therefore first exposed to be hit. The same effect was said to have been observed on another occasion in the campaign of Poland, where also, from the relatively large number of wounds of the hand, the men were accused of having intentionally mutilated themselves. But there can be no doubt that other shots, besides those of the enemy, have sometimes assisted in increasing the number of wounds of this particular part of the upper extremity. The awkwardness of young soldiers, not well habituated to the use of fire-arms, has led to accidental wounds in many instances. The fact of rear-rank men, when troops have been standing in double file, or, as often happened in Continental armies, in triple file, incautiously pointing their weapons in the direction of the hands of the front-rank men, has doubtless led to many more such injuries. The nature of the wounds pointed to these accidental causes in some of the instances examined by Baron Larrey, and they were mentioned in his report. During the Italian war of 1859, out of 15,383 wounds by projectiles shown in the hospital returns, there were more than one-seventh, viz., 2300, wounds of the hand and fingers. The proportion was higher, by nearly two-thirds, than the wounds of each of the other sections of the upper extremity. This large relative number of wounds of the hand is not attributed by Dr. Chenu to the causes which have just been mentioned, but to the nature of the fighting. Dr. Chenu

remarks that the sheltered defence of the Austrians in houses, farms, cemeteries, behind walls and entrenchments, necessitated, on the part of the assailants, escalades, manual exertion in breaking open doors, and, in short, a constant use of the hands in a direction toward the enemy, so that they were unavoidably exposed to the action of projectiles more than other parts of the body. As might be expected, the right hand is more frequently wounded than the left, being the more constantly exposed of the two. The proportion of shot wounds of the hands and fingers was also very large during the American war of the rebellion. The History states that out of 33,064 cases of fracture and contusion of the upper extremities, 11,369 were in the hands and fingers, and that over one-fourth of 54,729 shot flesh wounds of the upper extremities were flesh wounds of the hand.

Regional distribution of wounds among soldiers admitted into hospital.—It has been already mentioned that the only records of wounds usually kept are those which enumerate the number and nature of the wounds of men admitted into the hospitals for treatment. The relative proportions of these wounds, even if other conditions were alike, could not be expected to coincide with the numbers calculated according to the areal exposure of the regions concerned, nor with the distribution of the wounds inflicted in a given battle, when those directly fatal and those not directly fatal are calculated together. Many of the wounds inflicted in the regions of the head, neck, and trunk will have been attended with speedily fatal results; while most of the men wounded in the extremities will have survived to be admitted into the hospitals.

Experience in the French hospitals in 1859.—Dr. Chenu has given approximately the regional percentages of the wounds of 17,000 French soldiers who were admitted under hospital treatment for wounds and contusions of all descriptions during the Italian war of 1859. These percentages are shown in the table which follows. The relative numbers of the different kinds of projectiles by which the injuries were caused are also tabulated side by side with the bodily regions in which the wounds were inflicted.

Regional Distribution of Wounds.	Projectile by which the Wounds were caused.		
	Bullet.	Cannon-Shot.	Grape and Shell Fragments.
Head	5·6	...	12·0
Face	6·2	...	
Cervical Region . .	1·9	...	
Chest	8·3	...	41·0
Abdomen . . .	6·5	...	
Pelvis	2·9	...	
Scapulo-humeral Region	7·6	1·1	21·0
Arm	6·5	4·9	
Elbow	·8	·3	
Forearm	6·1	2·0	
Hand	19·3	1·1	
Thigh	12·2	40·8	26·0
Knee	2·4	·3	
Leg	10·3	46·7	
Ankle	1·9	2·8	
Foot	1·5		
Total . .	100·0	100·0	100·0

This furnishes the following regional distribution, when all the projectiles above named are included in one column, and the regional distribution is confined to the principal divisions to which Dr. Chenu found himself compelled to limit the wounds by grape and shell :—

Wounds of	All Projectiles Included.
Head, Face, and Neck	8·56
Trunk	17·56
Upper Extremity	23·56
Lower Extremity	48·30
Total	99·98

The proportionate numbers of wounds by projectiles in the four divisions of the body just named accord more nearly than might have been expected with the areal measurements of the same regions previously given, considering the many sources of disturbance of the calculated numbers which occur in actual warfare. When brought to a similar standard of one hundred parts, the areas of these regions, according to the ratios given in the preceding chapter, are—

Head, Face, and Neck	8·51
Trunk	28·91
Upper Extremity	21·14
Lower Extremity	41·41
Total	99·97

Regional distribution of wounds in military hospitals in other wars.—I have calculated the proportions of wounds in these four great divisions of the body in some other wars, the histories of which contain materials, more or less perfect, available for the purpose. In all but two of these instances, not excepting the Crimean war, in which siege operations took so large a part, the wounds of the lower extremities are in excess of those of the upper extremities. The number of wounds in the upper extremities was highest in the wars in New Zealand and on the Gold Coast. In these wars there was scarcely any fighting in clear, open ground. In New Zealand the larger number of the wounds were inflicted either by shot discharged from pits like rifle-pits, from stockades and pahs, after the British troops had got into close proximity to them, or in high and dense fern; and all these conditions would necessarily lead to the upper parts of the body being chiefly struck. On inquiring of my friend Sir Anthony Home, V.C., who took an active part in both these wars, whether his views on the cause of the higher proportion of wounds of the upper limbs in them coincided with what I have expressed above, he replied in the affirmative, and added: 'In the New Zealand war the wounds were nearly always received at close quarters. The Maoris had no powder to spare, and absolutely not a cap to throw away; they hardly ever fired except the shot appeared certain to take effect. Lying *perdus* either in the trench of their pah or in a hole, they waited until our men were on them—had, in fact, flushed them—and they then fired at the first part of their opponent visible, which would be the head or upper part of the body. Again, our men marched to attack through heavy fern, up to their middles or necks in it, and from this cause the lower half of the body was partly protected; for owing to the Maoris using bad powder and bad projectiles, the fern would occasionally suffice to turn the bullets.'

Very similar conditions existed in the war on the Gold Coast. Nearly all the fighting took place in the midst of tropical bush, in which the troops were able to protect the greater part of their bodies behind trees; while, in aiming and firing, the head, neck, and upper extremities would be necessarily exposed to the fire of their adversaries. Moreover, these were the parts which the enemy would naturally aim at, from the lower parts of the body being so much concealed. The large proportion of wounds of the head, face, and neck, compared with those of the trunk, in the Ashanti war, is notable from its contrast with the experience of other wars. The wounds of the head were 13·31 per cent. of the total number, of the face 12·23 per cent., neck 5·43 per cent.; or, together, 30·97 per cent., as shown in the table; while those of the chest were only 6·25 per cent., abdomen 4·62 per cent., back and spine 3·53, and perineum 0·82 per cent.; or, together,

Relative Proportions of Regional Wounds in certain Campaigns and Battles.

Campaign or Engagement	Crimea	Crimea, Commissioned Officers	Crimea, Non-Commissioned Officers and Men	Crimea, all Ranks combined	New Zealand, all Ranks combined	Danish War of 1864	Danish War of 1864	Langensalza and Kirchheilingen, 1866	Tauberbischofsheim, 1866	Sedan, 1870	Metz, 1870	Ashanti War, 1873–74	All the foregoing Campaigns and Battles
Nation	French	British	British	British	British	Prussians	Danes	Prussians and Hanoverians	Prussians and South Germans	French	Germans	British	Various
Number of Wounds specified	33,218	544	6984	7528	463	1968	1203	1092	297	579	875	368	47,588
Authority for the figures on which the proportions are calculated	Chenu	Official History	Official History	Official History	Army Medical Reports, vol. vii., 1867	Loeffler	Loeffler	Stromeyer	Beck	MacCormac	Fischer	Official Despatches	Various
Head, Face, and Neck	166·7	195·6	216·5	215·0	144·7	158·5	121·3	106·2	97·6	91·5	121·1	309·7	162·0
Trunk	164·9	221·4	148 3	153·6	198·7	168·7	234·4	167·6	164·9	214·2	187·4	152·2	181·5
Upper Extremities	315·0	202·9	306·1	298·6	343·4	308·9	263·5	273·8	202·0	253·9	284·6	304·4	279·7
Lower Extremities	353·4	380·1	329·1	332·8	313·2	363·8	380·7	452·4	535·3	440·4	406·8	233·7	376·8
Total	1000·0	1000·0	1000·0	1000·0	1000·0	999·9	999·9	1000·0	999·8	1000·0	999·9	1000·0	1000·0

wounds of the trunk 15·22 per cent. It will be seen that this percentage of wounds of the trunk, as compared with those of the head, face, and neck, is smaller than in any other war; and the peculiar circumstances, already mentioned, under which the fighting took place probably explain the difference. The wounds of the upper extremities are shown to be in greater excess over those of the lower extremities than in the war in New Zealand. It is probable that, in most wars in which bush-fighting predominates, similar proportions as regards wounds of the upper and lower extremities will be met with.

In the last part of the Surgical History of the War of the Rebellion,[43] there is a tabular statement of the relative frequency of wounds in the different regions of the body caused by shot. The figures are confined to wounds by projectiles, all other forms of injury being excluded. As regards the American Civil war, the total number of cases tabulated refer to the whole period from 1861 to 1865, and are 245,739 in amount. They do not include the cases of men killed in action. Of the total number mentioned, 26,400 were wounds of the head, face, and neck; 45,184 wounds of the trunk; 87,793 occurred in the upper extremities; and 86,413 in the lower extremities. The percentages were thus 10·7 in the head, face, and neck; 18·4 in the trunk; 35·7 in the upper extremities; and 35·1 in the lower extremities. The shot wounds of the upper extremities were therefore in the American war in excess of those of the lower extremities. This fact is thus explained in the text (p. 692): 'The protection afforded to the lower extremities and the trunk in the many siege operations by parapets, and in field operations, especially during the severe and extended campaign beginning with the battles of the Wilderness, Spottsylvania, Cold Harbor, and ending with the siege of Petersburg, by ditches, trenches, behind trees, &c., screened those parts to a large extent from injury, while the head and upper extremities were continually exposed to the practised eye of a vigilant foe.'

The American table also shows the distribution of wounds by shot, excluding other injuries, in twenty other wars and campaigns. The total number of cases recorded amount to 216,348, and of these 31,184 belong to the head, face, and neck; 45,583 to the trunk; 66,475 to the upper extremities; and 73,106 to the lower extremities; giving percentages of 14·4 to the head, face, and neck; 21·1 to the trunk; 30·7 to the upper, and 33·8 to the lower extremities. The large percentage of wounds of the extremities among the soldiers treated for shot wounds only, amounting in the United States hospitals to 70·8 per cent., is a noticeable fact. They also form a very considerable proportion of the shot wounds in the aggregate of cases treated during the twenty other wars quoted in the table, viz., 64·5 per cent. All

the statistics show, moreover, that there is not such a difference in the proportional numbers of shot wounds of the upper and lower extremities as might have been anticipated, merely judging from their difference in bulk and superficial target areas. On nearly every occasion the shot wounds of the upper and lower extremities closely approximate in their numbers, a fact sufficiently explained, as already pointed out, by the constant exposure to shot of the upper limbs, and the protection so frequently afforded to the lower limbs, in the ordinary procedures of warfare.

Average regional distribution of wounds among hospital patients in time of war.—If the hitherto observed average percentage of deaths on the field to wounds inflicted, shown at page 703, be accepted as a basis, it may be assumed that in every 1000 casualties in warfare there will be about 200 deaths on the field; and that of the remaining 800, taking the proportions resulting from a general summary of all the statistics previously quoted, there will be admitted into hospital, in European warfare, about 110 wounds of the head, face, and neck; 154 of the chest, abdomen, and pelvis; 252 of the upper extremities; and 284 of the lower extremities. But, as before stated, whether, under the new conditions of warfare, the proportions of wounds will remain in accord with previous experience, can at present be only a matter of surmise.

CHAPTER VI

RELATIVE FATALITY OF GUNSHOT WOUNDS IN DIFFERENT BODILY REGIONS

General causes which affect the ratios of mortality in gunshot injuries.—It is not the purpose of the remarks in this chapter to estimate the ratios of mortality among wounded men according to the effects produced by different kinds of projectiles, but rather to observe how far certain ratios of mortality have been preserved in wounds of different regions of the body when the fire-arms and projectiles by which they have been caused, and the circumstances under which they have been inflicted, have apparently been alike. Even under these conditions there will always be variations in the absolute mortality consequent on wounds of corresponding kinds, as well as variations in the relative rates of mortality of wounds in the separate regions. The nature of the engagement, whether it is one on a large scale or one of minor importance; the plan on which the surgical arrangements are conducted, whether it is one by which early assistance

can be given to the wounded, or one under which the first aid is delayed, or, in other words, the length of time the wounded are left on the field unattended to; the distance which has to be traversed before systematic surgical help can be reached; the nature of the ground and of the means of transport; the kinds of hospitals employed, whether tents, huts, or buildings, together with their forms and position; the number of the wounded collected in the separate hospitals; the amount of surgical attention and nursing care available; the state of general health of the troops as influenced by length of service in the field, circumstances in respect to diet, exposure, season, climate, temperature, and other conditions which I may have omitted to mention; all these matters exert an influence on the ratios of mortality from gunshot wounds shown in statistical returns, irrespective of differences in the wounds themselves. Some illustrations of the effects of a few of these circumstances follow.

As regards the future, there is every reason to expect that among the wounded who will come under hospital treatment the ratio of mortality will be considerably less than it has been hitherto, especially as regards men suffering from rifle-shot wounds. Not only will the nature of the wounds, from the narrowness of the projectiles, render very many of them less hazardous to life, but the improved means and methods of treatment will also, under ordinary circumstances, conduce to a far larger proportion of recoveries among the patients.

Effects of increase in dimensions of battles.—The absolute mortality among the wounded is always increased in vast battles like those of Königgrätz, Solferino, Gravelotte, and others. The wounded are so numerous, and fall within such comparatively short periods of time, that it becomes physically impossible, with the amount of hospital and sick-transport staff usually available, either to afford the necessary surgical aid, or to carry the wounded away to places where it can be obtained. Under such circumstances many men die from simple want of attention. It is an old remark that the percentage of mortality among men wounded in battle increases as their number is increased. It is obvious that this must arise from the fact that in small engagements the whole of the wounded can receive attention quickly; but that in large battles surgical care, adequate in amount, can hardly be given to any, while a large number must remain without any attention at all, or, at least, cannot receive it until too long a time has elapsed for it to be of much avail. The late Surgeon-General Dr. Loeffler of the Prussian army, basing his observations on experience gained in the slighter engagements and larger battles during the war between Prussia and Austria in 1866, proved that in almost every instance the mortality among the wounded of that campaign was increased concurrently with an increase in their numbers. The

following is Leoffler's table[44] showing the number of wounded in certain engagements, and the percentages of mortality among them :—

Number of Wounded.	Mortality among them.
54	3·7 per cent.
134	7·2 „
163	6·7 „
2496	10·5 „
7404	11·5 „

When the dimensions of the battles, and the numbers of the wounded, that may be expected in case of another European war are considered, owing to the probable masses of the opposing forces, the power and rapidity of the discharges of artillery and rifle projectiles, together with the increase, beyond all experience, in the difficulties of reaching the wounded owing to the enormous distances over which the rain of projectiles will extend, the general fact just described assumes a most serious aspect.

Increased ratio of mortality from aggregation of wounded.—The increased mortality which occurs from wounds when large numbers of wounded soldiers are collected together for treatment, in consequence of the morbid conditions generated by aggregation, is now fully recognised. The steps which have been taken to prevent accumulations of wounded, for combined treatment in large and often unsuitable buildings, have constituted one of the greatest improvements effected of late years in military medical administration. Nothing has more tended to diminish the preventible mortality among wounded men than the plan of treating them in separate and freely aërated huts or tents, while limiting the numbers collected in one locality as far as economical and transport considerations would allow. Circumstances will still occur in warfare which render an accumulation of wounded, at least for some time, unavoidable; but whenever this does happen, an increase in the absolute mortality among them may be expected to result, whatever pains may be taken to obviate it.

Apparent increase in ratios of mortality in certain wounds.—The following fact serves to illustrate the difference which there may appear to be in the fatality of certain wounds on different occasions among hospital patients, when the different mortality results are not due to any peculiarities in the wounds themselves, but are wholly attributable to extrinsic circumstances. During the Crimean war the percentage of fatality of chest wounds, all kinds being taken together, in the French military hospitals was 30·7 per cent. This ratio of mortality was almost the same as it was in the Crimean hospitals of the British army. In the French hospitals during the Italian campaign of 1859, however, the mortality was only 18·9 per cent. The altered rate of mortality shown in the hospital returns of the latter war cannot be said to have been due

to any diversity in the nature of the wounds inflicted in the field, nor in that of the treatment adopted in the hospitals, for the fire-arms and their projectiles were alike, and the same surgeons were in attendance; it was obviously attributable to the fact that the field hospitals in the Crimea were close to the places where the wounds were received, while in the Italian war they were mostly situated at a considerable distance from them. In the Crimea the patients were received into the ambulances shortly after their wounds had been inflicted; in Italy, owing to the largeness of the number of wounded resulting from the principal battles, the difficulties of transport, and the distance of the hospitals, many of the severer cases did not live long enough to come under treatment—they died on the field of action itself. The chest wounds among the 'killed in action' in Italy were increased in number; the deaths among those treated in hospital were, in proportion, lessened in number. The absolute mortality of the wounds of the chest was probably similar in both the Italian and Crimean wars.

Ratios of mortality in abdominal wounds.—The wounds most directly fatal in the field have generally been wounds of the head and chest. Penetrating wounds of the abdomen, even with visceral complications, are not so quickly fatal as a very large proportion of penetrating wounds of the two regions just named. A considerable number of penetrating wounds of the abdomen usually prove fatal, however, within twenty-four hours, or, at most, within a couple of days after their infliction. When, therefore, we find a large proportion of wounds of the abdomen among the dead on a field of battle and few in the hospitals, we may infer that there has been delay from some cause or other in removing the wounded; when we find a large ratio of mortality among wounds of the abdomen in the field hospitals, we may equally infer that the wounded have been removed to them without much delay. In the Crimean war the percentage of mortality in wounds of the abdomen among the British officers treated in the field hospitals was the highest of any regional wounds, viz., 51·5 per cent., and of the non-commissioned officers and men equally the highest of any regional wounds among them, viz., 55·7 per cent. This fact alone shows that no long time elapsed before the wounded officers and men referred to were placed under hospital care. In the French hospitals in the Crimea, also, wounds of the abdomen gave rise to a higher percentage of mortality than any other regional wounds, viz., 42·62 per cent.; while in the French hospitals in the Italian war of 1859 the mortality among them was only 26·64 per cent. These facts point to early removal to hospitals in the former instance, comparatively late removal in the latter.

Ratios of mortality according to the situation of hospitals.—It has often been noticed that the wounds of those who have

been treated in the villages and towns nearest to battle-fields have been followed by a larger ratio of mortality than those of the wounded treated in distant hospitals. Several reasons may be given for these different results. In the first place, the most gravely wounded, and from this cause the most unfit to be removed to distant hospitals—in many instances soldiers whose wounds are inevitably mortal—are retained in the nearest field hospitals; in the second place, the hospital arrangements in these situations are usually the most make-shift in character, the surgical appliances the most defective, and the hygienic conditions, within the hospitals and around them, not unfrequently very inferior. Opposite conditions have usually existed in the hospitals to which wounded soldiers have been sent at a distance from the scene of action. In these the slightly wounded have mostly been received, together with those who have partly recovered from their injuries, or from the surgical operations consequent on them—in short, all those who have been likely to undergo the fatigues and exposure of the transport with impunity; while the hospitals in such situations, being for the most part fixed establishments, have been provided with all the necessary means for the treatment of their inmates, and have had a more complete professional and nursing staff. The statistics of wounds, and of the different results of their treatment, in different places, will often lead to wrong conclusions, unless such facts are borne in mind.

Regional fatality of wounds on the field of action itself.—There are not many data for estimating the relative mortality of wounds of different regions on the field of battle itself. The pressure on the time of surgeons in attending to the living wounded rarely permits the opportunity of examining the nature, or even the mere situation, of the wounds of those who have been killed outright. It could not possibly be done after large battles. The observation has been made to a partial extent on several occasions. During the New Zealand war of 1863–65, the region of the body wounded in 118 men who were killed on the scene of action itself was noted, and is recorded in the official report of the war.[45] The following table shows the number of wounds in each region on this occasion, and the percentages of their occurrence :—

Region.	Killed on the Spot.	Percentage.
Chest	59	50·00
Head	40	33·90
Abdomen	11	9·32
Neck	4	3·39
Thigh	4	3·39
Total . . .	118	100·00

It is stated in the Surgical History of the U. S. War of the Rebellion, that out of the 44,238 soldiers killed in action, according to the adjutant-general's returns, the records in the surgeon-general's office only show the seat of injury in 1173 of the number. Of these, 487 were wounded in the head and neck, 603 in the chest and abdomen, 30 in the upper, and 53 in the lower extremities.[46] These figures show the relative regional fatality to have been 41·51 per cent. in the head and neck, 51·41 in the trunk, 2·56 in the upper extremities, and 4·52 in the lower extremities, among 1173 wounds which led to immediate death in the field itself.

Regional fatality of wounds within forty-eight hours.—Dr. Loeffler, in his account of the Danish war of 1864, has recorded the regional distribution of the wounds of 387 Prussians who were killed directly on the field of action (33 killed, the situations of whose wounds were not noted, being excluded), as well as of 82 others who died during the first forty-eight hours from their injuries.[47] On calculating the percentages derived from these figures, the order of mortality of the regional wounds is not found to differ, as appears in the adjoining table, very materially from that in the one preceding.

Region.	Killed on the Spot.	Died within 48 Hours.	Total Killed and Died.	Percentage of Killed on the Spot.	Percentage of Dead in First 48 Hours.
Chest . . .	196	13	209	50·65	44·56
Head . . .	117	20	137	30·23	29·21
Abdomen and Pelvis	44	34	78	11·37	16·63
Lower Extremities .	13	7	20	3·35	4·27
Neck . . .	8	3	11	2·07	2·35
Back . . .	7	3	10	1·81	2·13
Upper Extremities .	2	2	4	0·51	0·85
Total . .	387	82	469	99·99	100·00

It will be seen by these figures that the order of fatality according to regions is only slightly changed by adding those who succumbed during the first forty-eight hours, from what it is among those who were killed on the field itself. The numbers of deaths differ considerably in the two lists; but the order of regional fatality in those who were killed on the spot is but little altered by the addition of those who may be regarded as having been in a dying state at the time they were removed from the field to the field hospitals. The deaths among men wounded in the trunk and head, doubtless with lesions of the internal organs, are largely increased in number in the course of forty-eight hours.

Regional fatality of wounds among patients in military hospitals.—It will be readily understood that when those who are

killed on the field itself, and those who die within forty-eight hours after an action, are excluded, the regional order of fatality among those who remain under treatment may become materially changed. The severe wounds of those regions, the wounds of which are attended with the most speedily fatal results, have in a large proportion disappeared from the hospital lists, and the less serious wounds among them only remain for treatment. It is especially among these that more favourable results may be hoped for in the future from improved modes of treatment than have been experienced in the past.

There are so many sources of fallacy when the percentages of mortality are derived from limited numbers of cases in particular hospitals (some of the causes of which have been already explained), that I have preferred to select a few examples in which the number of wounded treated throughout a whole war, or resulting from an entire battle, could be obtained, and the number of deaths among them shown. As these figures must include the results of treatment both in the near and distant hospitals, and under all conditions, a closer approximation to the truth may be hoped for than could be attained by selecting disjointed results. The only exception I have introduced has been the partial experience gained in the hospitals at Sedan and Balan by Sir Wm. MacCormac and Dr. Frank. As this experience was gained in hospitals on the field of action itself, to which the wounded were brought indiscriminately from the conflict, and where circumstances allowed the patients to remain for a considerable time, the figures may perhaps be fairly taken as a sample of what would have been the experience if the statistics of the whole of the wounds inflicted in the great and decisive battle of Sedan could have been ascertained.

The campaigns or battles respecting which sufficient information has been found to exist for basing the calculations just mentioned upon are the following: Crimean and Italian wars, French; Crimean war, British; New Zealand war, British; war of 1864, Prussians and Danes; Ashanti war, British; and the campaign between Prussia and Hanover in 1866. Calculations founded on Sir Wm. MacCormac's observations at Sedan have also been added, as already mentioned.

Regional fatality of wounds among French soldiers during the Crimean war.—The following tables show the order of fatality of the wounds and surgical operations necessitated by them, among the cases treated in the ambulances and hospitals of the French army during the Crimean war, and the subsequent Italian campaign of 1859.[48] Owing to the manner in which the wounds are classified in Dr. Chenu's very valuable histories of these wars, the regions cannot be arranged, or the percentages calculated, in exactly the same manner as they are in the British tables. Wounds penetrating the articulations, for example, are not separated from those affecting the parts simply surrounding the articulations.

Other differences in details exist, which interfere with exact comparison between the French and British returns.

Crimean War, 1854–56.—French.					Italian Campaign, 1859.—French.				
Order of Fatality.	Region.	Number Wounded.	Number Died.	Percentage of Mortality.	Order of Fatality.	Region.	Number Wounded.	Number Died.	Percentage of Mortality.
1	Abdomen[49] . .	610	260	42·62	1	Back, Sacro-lumbar, Iliac and Glutæal .	361	122	33·80
2	Lower Extremities[50] .	11,413	4289	37·6	2	Abdomen . .	1013	263	25·96
3	Neck . . .	435	146	33·6	3	Neck . . .	203	43	21·18
4	Perineum and Genito-Urinary Organs .	234	77	32·6	4	Head . . .	779	156	20·03
5	Chest . . .	2606	817	31·35	5	Chest . . .	1052	199	18·92
6	Back, Sacro-lumbar, Iliac and Glutæal .	1947	616	31·64	6	Perineum and Genito-Urinary Organs .	106	20	18·86
7	Head . . .	2711	761	28·0	7	Lower Extremities . .	7704	1337	17·35
8	Upper Extremities	8803	2115	24·0	8	Face . . .	955	114	11·94
9	Face . . .	2392	444	18·5	9	Upper Extremities	6721	6591	9·80
	Total .	31,151	9525	30·57		Total .	18,894	2913	15·41

Regional fatality of wounds in the British hospitals during the Crimean war.—The next table shows the order of fatality of the wounds according to regions, firstly among the officers, and secondly among the non-commissioned officers and privates, treated in the British hospitals during the Crimean war. The wounds of the officers are quoted for the whole of the war; of the rank and file, from April the 1st, 1855, to the end of the war.[51]

Crimean War, 1854–55.—*British.*

Officers.					Non-Commissioned Officers and Privates.				
Order of Fatality.	Region.	Number Treated.	Number Died.	Percentage of Mortality.	Order of Fatality.	Region.	Number Treated.	Number Died.	Percentage of Mortality.
1	Abdomen . .	33	17	51·5	1	Abdomen . .	235	131	55·7
2	Chest . . .	54	17	31·5	2	Perineum and Genito-Urinary Organs .	55	17	30·9
3	Joints . . .	10	3	30·0	3	Chest . . .	420	118	28·1
4	Head . . .	47	8	17·0	4	Joints . . .	121	25	20·7
5	Neck . . .	19	2	10·5	5	Head . . .	851	170	20·0
6	Back and Spine .	29	3	10·3	6	Back and Spine .	326	45	13·8
7	Lower Extremity.	200	10	5·0	7	Lower Extremities	2215	174	7·8
8	Upper Extremity.	108	4	3·7	8	Neck . . .	128	4	3·1
9	Perineum and Genito-Urinary Organs .	4	0	0·0	9	Face . . .	533	14	2·6
10	Face . . .	40	0	0·0	10	Upper Extremity	2100	55	2·6
	Total . .	544	64	11·76		Total . .	6984	753	10·78

Regional fatality of wounds in the last New Zealand war.—The order of fatality among the gunshot wounds and injuries received during the war in New Zealand from May 1863 to June 1865 is next shown.[52] It includes the wounds among officers, non-commissioned officers, and privates.

New Zealand War.—British Officers, Non-Commissioned Officers and Men.

Order of Fatality.	Region.	Number of Wounds.	Deaths.	Percentage of Mortality.
1	Blood-vessels	2	2	100·00
2	Abdomen	23	14	60·87
3	Chest	38	14	36·84
4	Head	36	11	30·55
5	Back and Spine	25	6	24·00
6	Joints	33	5	15·15
7	Face	21	1	4·76
8	Lower Extremities	133	6	4·51
9	Upper Extremities	132	0	0·0
10	Perineum, and Genito-Urinary Organs	5	0	0·0
11	Neck	10	0	0·0
12	Nerves	5	0	0·0
	Total	463	59	12·96

Regional fatality of wounds after the battle of Waterloo.—Sir Charles Bell has left a manuscript note on this subject in an interleaved book which he used at Brussels, and in which he recorded some observations collected in his visits to the hospitals to which the wounded were taken after the battle of Waterloo.[53] He remarks that the following is the order of importance of the regions of the body as regards gunshot wounds: 1, abdomen; 2, chest; 3, head; 4, joints; 5, large bones. The volume in which this annotation occurs is preserved at Netley. The correctness of Sir C. Bell's observation is closely confirmed by the experience of the Crimean and New Zealand wars, shown in the foregoing tables.

Regional fatality of wounds in the war of 1864 and on other occasions.—The mortality of gunshot wounds according to bodily regions in the Prusso-Danish war of 1864 has been deduced from the returns published by Dr. Loeffler.[54] The wounded among the Danes, shown in the second half of the table, are those who were treated in the Prussian hospitals, and as it may well be supposed that most of the Danish wounded effected their escape whose wounds did not prevent them from doing so, they may be regarded as having consisted of the men whose cases presented the most severe characters. This will probably explain the higher ratios of mortality among the regional injuries on the Danish side

of the table, as compared with those shown on the previous section, which refers to the Prussian wounded.

Prusso-Danish War of 1864.

Prussians.					Danes.				
Order of Fatality.	Region.	Number Wounded.	Number Died.	Percentage of Mortality.	Order of Fatality.	Region.	Number Wounded.	Number Died.	Percentage of Mortality.
1	Blood-vessels . .	3	3	100·00	1	Chest . . .	113	76	67·25
2	Abdomen . .	103	59	57·28	2	Abdomen . .	89	57	64·04
3	Chest . . .	137	57	41·60	3	Joints . . .	57	28	49·30
4	Joints . . .	43	17	39·50	4	Back and Spine .	80	32	40·00
5	Back and Spine, and Glutæal Region .	92	27	29·34	5	Blood-vessels .	6	2	33·33
					6	Lower Extremities	458	146	31·87
					7	Head . . .	61	19	31·1
6	Head . . .	161	24	14·9	8	Upper Extremities	252	32	12·7
7	Lower Extremities	716	90	12·57	9	Neck . . .	26	2	7·69
8	Neck . . .	40	4	10·00	10	Face . . .	59	3	5·1
9	Upper Extremities	555	33	5·9	11	Nerves . . .	2	0	0·0
10	Face . . .	111	1	0·9					
11	Nerves . . .	7	0	0·0					
	Total . .	1968	315	16·00		Total . .	1203	397	33·00

The ratios of mortality among the regional wounds treated during the short campaign between Prussia and Hanover in 1866 are as follows:—

Langensalza and Kirchheiligen.

Order of Fatality.	Region.	Number Treated.	Number Died.	Percentage of Mortality.
1	Spine	8	6	75·00
2	Chest	102	32	31·37
3	Joints	95	29	30·52
4	Abdomen	70	21	30·00
5	Head	46	10	21·74
6	Lower Extremities	433	48	11·85
7	Neck	18	2	11·11
8	Upper Extremities [55]	264	20	7·57
9	Face	51	2	3·92
10	Perineum and Genito-Urinary Organs	5	0	0·00
	Total	1092	170	16·48

The number of wounded soldiers treated after the battle of Sedan, and the resulting deaths among them recorded by Sir Wm. MacCormac, give the following ratios according to the several regions of the body injured:—

Sedan.
(MacCormac.)

Order of Fatality.	Region.	Number Wounded.	Number Died.	Percentage of Mortality.
1	Abdomen	12	8	66·6
2	Head	17	9	52·9
3	Joints	44	23	52·2
4	Chest	54	19	35·2
5	Back and Spine	24	8	33·3
6	Lower Extremities	264	54	20·4
7	Face	29	5	17·3
8	Upper Extremities	130	11	8·5
9	Neck	5	0	0·0
10	Various (not specified) . . .	31	0	0·0
	Total	610	137	22·45

General results of the foregoing observations.—On adding together the mortality results in the tables which can be most safely combined in regard to correspondence in classification, viz., those of the Crimean, New Zealand, and Italian wars, the Prusso-Danish war of 1864, the Hanoverian campaign of 1866, and MacCormac's experience at Sedan, the general result is as follows:—

Regions.	Crimean War. British Officers.	Crimea. British N.-C. Officers and Privates.	New Zealand. British.	Crimea. French.	Italian War. French.	1864. Prussians.	1864. Danes.	1866. Germans.	1871. Sedan.	Total Average from the Mean of the Ratios.
Abdomen . .	51·5	55·7	60·87	42·62	25·96	57·28	64·04	30·0	66·6	50·51
Chest . .	31·5	28·1	36·84	31·35	18·92	41·60	67·25	31·37	35·2	35·79
Head . .	17·0	20·0	30·55	28·0	20·03	14·9	31·1	21·74	52·9	26·24
Neck . .	10·5	3·1	0·0	33·6	21·18	10·0	7·69	11·11	0·0	10·80
Back and Spine	10·3	13·8	24·0	31·64	33·80	29·34	40·0	75·0	33·3	32·36
Lower Extremity	6·3	8·23	7·64	37·6	17·35	12·57	31·87	14·26	23·7	17·72
Upper Extremity	3·6	3·1	0·67	24·0	9·80	8·3	19·4	9·03	13·1	10·11
Perineum .	0·0	30·9	0·0	32·9	18·86	0·0	0·0	0·0	0·0	13·78
Face . . .	0·0	2·6	4·76	18·5	11·94	0·9	5·1	3·92	17·3	7·24

The late Professor De Chaumont of the Army Medical School calculated for me the corrected mean of the foregoing averages of mortality in wounds of different regions. The following table shows side by side the averages obtained from the total number of cases and deaths in each regional series, while the last column exhibits the corrected results according to Dr. De Chaumont's calculation. The terminal figures may be accepted as the most reliable.

Summary of the Percentages of Deaths to Wounded treated, according to Regions.

Regions.	Cases.	Deaths.	Averages obtained from the Total Numbers.	Averages obtained from the Ratios of each Group.	Mean of the above Averages.	Corrected Mean.[56]
Abdomen . . .	2,188	830	37·935	50·508	44·221	43·825
Chest	4,576	1,349	29·480	35·792	32·636	31·932
Back and Spine .	2,892	865	29·910	32·364	31·132	29·514
Perineum . .	409	114	27·873	13·777	20·825	24·696
Head	4,709	1,168	24·803	26·244	25·523	24·101
Lower Extremities .	23,704	6,212	25·819	17·724	21·771	22·033
Neck	884	203	22·964	10·798	16·881	13·632
Upper Extremities .	19,312	3,002	15·545	10·112	12·828	12·975
Face	4,191	584	13·935	7·244	10·589	10·547

In the concluding volume of the Surgical History of the War of the Rebellion in the United States, there is a table which shows the percentages of fatality in 233,884 out of 245,790 gunshot wounds. The results of the remaining 11,906 wounds were undetermined. The following are the figures in the table referred to:[57]—

Table indicating Percentage of Fatality of Shot Wounds recorded during the War of the Rebellion.

Seat of Injury.	Total Cases.	Results.			Percentage of Fatality.
		Recoveries.	Deaths.	Undetermined.	
Shot Injuries of the Head . .	12,089	6,573	2,676	2,840	28·9
,, ,, Face . .	9,416	7,406	462	1,548	5·8
,, ,, Neck . .	4,895	3,496	618	781	15·0
,, ,, Spine . .	642	279	349	14	55·5
,, ,, Chest . .	20,264	13,921	5,373	970	27·8
,, ,, Abdomen .	8,438	3,455	3,293	1,690	48·7
,, ,, Pelvis . .	3,159	2,194	930	35	29·7
Shot Flesh Wounds of the Back .	12,681	10,883	800	998	6·9
Shot Injuries of Upper Extremities	87,793	80,090	5,608	2,095	6·5
,, Lower Extremities	86,413	73,665	11,813	935	13·8
Aggregate . . .	245,790	201,962	31,922	11,906	13·6

If the seats of injury in this table be assimilated as nearly as they can be to the summary of percentages given on the top of this page, the following will be the order of fatality among the 233,884 cases of gunshot wounds the results of which had been determined and recorded during the United States war of the Rebellion:—(1) Abdomen, deaths, 48·7 per cent.; (2) Pelvis,

29·7; (3) Head, 28·9; (4) Chest, 27·8; (5) Neck, 15·0; (6) Lower Extremities, 13·8; (7) Back and Spine, 9·3; (8) Upper Extremities, 6·5; (9) Face, 5·8 per cent.

Progressive mortality among wounded men under hospital treatment according to duration of time.—The following table, though not complete, as the time of the receipt of the wound prior to the time of death was not recorded in 409 cases, possesses a certain amount of interest, as it shows the rate of progression of the fatal results in 1072 cases of wounds and injuries which led to death in the British hospitals at the time of the Crimean war:[58]—

Duration under Treatment.	Number of Deaths.
Under 1 day	160
1 day, but under 2 days	149
2 days ,, 3 ,,	91
3 ,, ,, 4 ,,	66
4 ,, ,, 5 ,,	47
5 ,, ,, 6 ,,	51
6 ,, ,, 7 ,,	44
7 ,, ,, 8 ,,	30
8 ,, ,, 2 weeks	167
2 weeks ,, 3 ,,	93
3 ,, ,, 4 ,,	45
4 ,, ,, 5 ,,	49
5 ,, ,, 6 ,,	21
6 ,, and over 6 ,,	59
Period unknown	409
Total	1481

The large preponderance of deaths which occurred in the first week, when contrasted with those in subsequent weeks, is very noticeable in the foregoing table. Thus of 1013 wounded patients, in whose cases the date of fatal termination was noted during the first six weeks, there died in the first week, 638; in the second, 167; in the third, 93; in the fourth, 45; in the fifth, 49; in the sixth, 21. When this progressive rate of decrease from death is added to that from the returns to duty, an approximate idea can be formed of the amount of hospital accommodation which will probably become vacant among any given number of wounded men under treatment, in certain periods of time, from these two sources combined.

Progressive recoveries of wounded patients under hospital treatment.—The following table, also derived from the Surgical History of the Crimean War, supplies this information in respect to 4015 men who returned to duty out of a number of 6359 wounded men treated.

Duration of Treatment.	Returned to Duty.	Ratio per Cent. returned to Duty.
Under 1 week	1476	23·2
Over 1 „ but under 1 month .	1408	22·1
Over 1 month „ 2 months .	709	11·1
Over 2 months „ 3 „ .	263	4·1
Over 3 „ „ 4 „ .	101	1·6
Over 4 „ „ 5 „ .	40	0·6
Over 5 „ „ 6 „ .	11	0·1
Over 6 „	7	0·1
Total returned to duty . .	4015	63·1

The progressive rates of mortality and recovery, as well as the relative numbers of deaths and recoveries, will probably be found to be considerably modified by the effects of improved methods of treatment on occasions of war in the future. The experience derived from the Crimean war and noted in the last two tables will at least serve for purposes of comparison.

CHAPTER VII

PROPORTIONS OF SLIGHT TO SEVERE WOUNDS IN BATTLE

In the appendix to the first edition of my work on Ambulance Transport, some tables were inserted showing the ratios of comparatively slight to severe wounds so far as the experience gained in certain wars had afforded information on the subject. Their purpose was to form the basis of an estimate for determining the amount of transport to be supplied at the commencement of a campaign for the removal of wounded men in a sitting posture, and the amount required to admit of patients being carried recumbent. The tabulated wounds of the Crimean and New Zealand wars, and also of the war of the Rebellion in the United States, so far as information regarding it was then available, were separated into two groups—one consisting of such wounds as might be supposed not to prevent the subjects of them from maintaining a sitting position, the other of those usually found to necessitate the removal of the patients lying down. As these ratios are useful for reference, I insert them here, with later information as regards the United States war, and the addition of a column derived from Surgeon-General Stromeyer's returns of the Prusso-Hanoverian conflict of 1866. I have not met with

other numerical returns for entire campaigns capable of being arranged precisely under the same headings as those of the Crimean and New Zealand wars.

A. *Slighter Wounds, the Subjects of which might be Transported Sitting.*

Description of Wounds.	Crimea. N.-C. Officers and Men.	Crimea. Commissioned Officers.	New Zealand. N.-C. Officers and Men.	New Zealand. Officers, N.-C. Officers and Men.	United States.	Prusso-Hanover, 1866.
Wounds of Head without known depression or penetration of Bone	691	40	23	25	8,067	29
Flesh Wounds of Face, and Wounds with slighter forms of injuries to Bones of Face . . .	382	33	13	14	4,914	26
Flesh Wounds of Neck . . .	128	19	8	10	4,789	16
Wounds of Chest (non-penetrating)	255	25	9	12	11,995	49
Wounds of Abdomen (non-penetrating)	101	14	8	8	4,707	7
Flesh Wounds of Back . . .	299	24	17	19	12,681	0
Wounds of Upper Extremities .	2,083	106	145	156	87,793	299
Wounds of Lower Extremities (Flesh Wounds) . . .	792	66	56	61	59,139	317
Total	4,731	327	279	305	194,085	743

B. *Severer Wounds, the Subjects of which mostly require to be Transported Lying Down.*

Description of Wounds.	Crimea. N.-C. Officers and Men.	Crimea. Commissioned Officers.	New Zealand. N.-C. Officers and Men.	New Zealand. Officers, N.-C. Officers and Men.	United States.	Prusso-Hanover, 1866.
Wounds of Head, with depression or penetration of Bone .	160	7	9	11	4,022	17
Wounds of Face, implicating Bones	151	7	6	7	4,502	25
Wounds of Neck, complicated .	...	...	...	...	106	...
Wounds of Chest, penetrating or injuring Bones	165	29	22	26	8,269	55
Wounds of Abdomen (penetrating)	134	19	10	15	3,731	12
Wounds of Perineum and Pelvis .	55	4	5	5	3,159	55
Wounds of Back, with injury to Spine	27	5	5	6	642	8
Wounds of Lower Extremities, with or without Fractured Bones	1,406	134	73	79	27,274	133
Wounds of Nerves, Vessels, and Joints	155	12	6	9	...[59]	44
Total	2,253	217	136	158	51,705	349

Table showing the Ratios of (A) *Slighter Wounds, the Subjects of which might be Transported Sitting, to* (B) *Severer Wounds, the Subjects of which mostly require to be Transported Lying Down.*

Description of Wounds.	Crimea. N.-C. Officers and Men.	Crimea. Commissioned Officers.	New Zealand. N.-C. Officers and Men.	New Zealand. Officers, N.-C. Officers and Men.	United States.	Prusso-Hanover 1866.
(A) Wounded Patients for sitting position	4,731	327	279	305	194,085	743
(B) Wounded Patients for recumbent position	2,253	217	136	158	51,705	349
Total Wounds specified	6,984	544	415	463	245,790	1,092
Percentage of (A) Patients sitting	67·9	60	67·2	65·9	78·9	68·0
Percentage of (B) Patients recumbent	32·1	40	32·8	34·1	21·1	32·0

Ratios of slight to severe injuries in the Crimean and Italian wars in the French army.—Although the classification adopted by Dr. Chenu in his valuable surgical histories of the Crimean and Italian wars prevent the injuries tabulated by him from being arranged in exact accord with the plan adopted in the foregoing tables, an approximate estimate of the proportion of slight to severe wounds may perhaps be arrived at by classing those which are shown to have become healed without having caused the patients to quit the service, as comparatively slight wounds, and those necessitating retirement from the army or leading to death, as severe wounds. It is hardly probable that any very severe injuries to nerves, bones, cavities, or viscera could have occurred without having resulted either in the death, pensioning, or retirement from the army of the patients concerned. The inference is, therefore, that those wounds which have not been included under either of these headings, but simply under the heading of 'Healed,' were relatively slight injuries.

It is on this principle that the distinction has been made in the following tables. The numbers under 'Slight' are those which are recorded as 'Guéris' by Dr. Chenu; the numbers under 'Severe' are those which are recorded by him under the headings of 'Retraités,' 'Pensionnés temporairement,' and 'Morts.'[60] It will be seen that, even under this different mode of proceeding, the percentages of the total numbers approximate very closely to those shown in the previous tables.

Crimean Campaign.—French Army.

Regions of Wounds.	Total.	Slight.	Severe.	Percentages.	
				Slight.	Severe.
Head	2,711	1,827	884	67·4	32·6
Face	2,372	1,494	878	62·9	37·1
Neck	435	272	163	62·5	37·5
Chest	2,657	1,735	922	65·3	35·7
Back	1,950	1,262	688	64·7	35·3
Abdomen	550	338	212	61·48	38·5
Perineum	381	210	171	54·16	45·9
Upper Extremities . . .	9,466	6,295	3,171	66·5	33·5
Lower Extremities . . .	11,743	5,871	5,872	50·0	50·0
Total . . .	32,265	22,475	9,790	69·66	30·34

Italian Campaign, 1859.—*French Army.*

Regions of Wounds.	Total.	Slight.	Severe.	Percentages.	
				Slight.	Severe.
Head	779	566	213	72·7	27·3
Face	955	607	348	63·6	36·4
Neck	203	139	64	68·5	31·5
Chest	1,052	663	389	63·1	36·9
Abdomen	917	642	275	70·1	29·9
Back	361	103	258	28·7	71·3
Perineum	202	118	84	58·5	41·5
Upper Extremities . . .	6,721	4,339	2,382	64·6	35·4
Lower Extremities . . .	7,704	5,144	2,560	66·8	33·2
Wounds not determined . .	778	729	49	93·7	6·3
Total . . .	19,672	13,050	6,622	66·33	33·67

Ratios of slight to severe wounds in the war of 1870–71.— One of the tables (Table A) in Fischer's statistics of the losses in the Prussian and North German armies during the war of 1870–71, indicates the proportions of severe and slight wounds, but the figures contain many elements of uncertainty. It will be observed that no information is afforded respecting more than 30 per cent. of the total number. The summary of Fischer's table is as follows:—

Nature of Injury.	Number Injured.	Percentage of Injuries.
Killed	7,735	8·7
Slight Wounds	30,379	34·0
Severe Wounds	23,054	26·0
Wounds without indication whether they are slight or severe .	3,729	4·3
Wounds, nature not specified . .	23,717	26·7
Accidental Injuries, not gunshot . .	263	0·3
Total . . .	88,877	100·0

General conclusion on the subject.—It may be roughly estimated, from the most reliable of the foregoing observations, that, excluding those injuries which prove directly fatal on the field of action itself, between one-fourth and one-third of the remainder may be classified as severe, and from two-thirds to three-fourths as slight injuries.

CHAPTER VIII

ACCIDENTAL GUNSHOT INJURIES IN WAR-TIME

THE gunshot injuries which occur in time of war are not all produced by the fire of the enemy, Some are accidental, and the number of these is often far greater than might be anticipated. Inadvertence and the premature discharge of fire-arms in the hands of soldiers, wounds inflicted accidentally on comrades, the accidental ignition of cartridges, or explosions of shells, powder cases, and magazines, are the ordinary sources of these injuries. During the Crimean war many officers armed themselves with revolver-pistols, and the wounds caused by these weapons among those who carried them, from want of sufficient care, were by no means few in number, and sometimes led to very serious results.

Accidental gunshot wounds in the New Zealand war.—The accidental wounds occurring in campaigns are rarely distinguished in the numerical returns from those which result from the fire of the enemy. The distinction is, however, noted in the Surgical Report of the New Zealand War of 1863–65.[61] The recorded number of gunshot wounds among the men in this war was 415, and of this number 28 were accidental, or nearly 7 per cent. Of these 28 accidental wounds, 10 took place in the Wanganui campaign, where the number of wounds inflicted by the enemy was only 68; so that one-seventh of the gunshot wounds were accidental on this occasion. Six of the 10 were self-inflicted wounds of the hand, but there was no ground for suspecting them to have been done designedly.

Accidental injuries of various kinds in campaigning.—When accidental surgical injuries of all kinds occurring in the course of a campaign are taken together, such as contusions and strains during the manipulation of heavy guns as well as in the use of smaller fire-arms, together with the different kinds of injuries which result from the very varied occupations in which troops have to employ themselves while on active service before an enemy, the number sometimes mounts to a considerable figure. As these injuries generally result from the military operations

in progress, they, as a rule, appear in the hospital returns with all the other injuries resulting from the war in which the troops are engaged. It then ceases to be possible to eliminate them from those which are inflicted by the enemy. They sometimes swell the figures in the numerical returns to so large an extent, that, when practicable, they should be separated from the injuries inflicted by the enemy in action. Thus the number of injuries treated in the British hospitals during the Crimean war was 18,283. But of this number 6768, or considerably more than one-third, were accidental injuries not occurring in action;[62] so that the number of those which were actually received in battle becomes reduced to 11,515.

There is no reason for supposing that the proportion of accidental wounds and injuries in this instance differed materially from what generally occurs with armies in the field. The injuries included in Dr. Chenu's tables of the Crimean and Italian wars, under the heading of 'Causes Diverses,' were probably composed in large number of accidental injuries of the classes above mentioned, and some of the injuries included in the column of gunshot wounds may have had a similar origin. The number of accidental wounds of the kind cannot, however, be determined, as information on the subject is not forthcoming.

CHAPTER IX

ULTIMATE RESULTS OF GUNSHOT WOUNDS RECEIVED IN WARFARE

General remarks.—The final results of gunshot injuries, excluding those which have proved fatal on the field of action, are shown in military returns under the following categories: 1. Discharged to duty; 2. Invalided, or discharged from military service; and 3. Died under treatment. The state of those who are invalided is left undefined in the numerical returns; it is only shown in the technical reports, or sometimes in special tables appended to the regional classes of wounds to which the injuries of the men invalided have happened to belong.

Statistics of the proportionate numbers of wounded men who have recovered and returned to duty in different wars are so far important, as they afford an indication of the probable extent of restoration from this source of the strength of a combatant force after it has been lessened by action with an enemy; the statistics of the numbers invalided are important so far as they show the probable number of invalids who may be expected to require support from the country, and of men who will return more or less disabled

to the civil population, from which they were originally drawn as able-bodied recruits.

Exact statistics of the ultimate results of gunshot injuries not readily obtainable.—It might well be supposed that no difficulty would be met with in obtaining the necessary information from the records of a well-organised army for furnishing exact replies to the following questions: How many men were wounded in a given campaign? Of this number, how many died on the field? How many eventually died from the effects of their wounds? How many returned to duty with their corps, and after what periods of absence? and how many were discharged as unfit for further military service on account of their injuries? But on examining military statistical records, it will be found that in hardly any instance are the figures supplied from which this information can be obtained with positive accuracy. And, upon consideration, it may be readily understood why such records are usually defective. The frequent changes of hospital residence, in time of war, before a wounded soldier reaches the one where he is finally disposed of; the casualties which occur while the patients are *in transitu;* irregularities in furnishing hospital returns; occasional errors and omissions in them; the interruptions which frequently result merely from the rapid succession of events; the changes from one occupation to another of the medical officers in charge of patients—these and other such circumstances constantly act as impediments to the supply of complete and accurate information at the time the occurrences take place; while, if not furnished at the time, the difficulties in the way of collecting it subsequently are almost insuperable.

To give the complete results so far as British troops are concerned, not only the wounded men who die on the field, or while under treatment in the hospitals at the seat of war, or who are sent back to duty from them, or discharged to be invalided to England, must be shown; but also those who die while on the way between the various halting stations and hospitals on shore, as well as during the sea-passage home, and after arrival in England. Those who are discharged from the home hospitals to duty, or discharged as invalids out of the service, must also be duly tabulated. Only by all these means taken together can the final results of all the injuries inflicted in a given action or campaign be truly shown. And of those soldiers even who are sent back to their regiments, some, after a short time, prove themselves incompetent for the duties which devolve on them, and then have to be discharged from further service. Thus the final results of the injuries inflicted in any given war can only be accurately shown after a certain time has elapsed subsequently to its conclusion. But, for all practical purposes, it is generally sufficient to exhibit the results up to the time of the disposal of the wounded men when the

period of their hospital treatment has been concluded. This, it need hardly be said, will comprehend the whole course of treatment in the various hospitals through which the patient may have passed, whether by transference from one field hospital to another, from the seat of war to the home country, or from one home hospital to another.

Ultimate results of wounds inflicted during the Crimean war and treated in British hospitals.—The whole of this information is complete as to the British troops wounded in battle during the Crimean war, and is shown in the following tables.[63] I have been unable to obtain similar information in respect to any other war.

Wounds and Injuries received in Action.—Results of Hospital Treatment.

War.	Number of Polemical Wounds among British Troops admitted into Hospital.	Died in the Field and General Hospitals, or on Board Ship to the Bosphorus.	Discharged to Duty.	Invalided to England.
Crimea . .	11,515	1,758	6,439	3,318

Invalided to England.	Died on Passage Home.	Died in Hospitals in England.	Discharged to Duty.	Discharged from Service.
3,318	13	4	290	3,011

The final disposal of the 11,515 polemically wounded men admitted for hospital treatment was then as follows :—

Number of Wounded admitted into Hospital.	Died in Hospital or on Board Ship.	Percentage of Deaths.	Discharged to Duty.	Percentage of Discharged to Duty.	Discharged from further Service.	Percentage of Discharged from further Service.
11,515	1,775	15·41	6,729	58·44	3,011	26·15

Application of the foregoing statistics.—If these, with previous data, be applied to the wounds caused by battle, then out of every 100 casualties there may be expected to be about 20 deaths on the field itself; and of the remaining 80 wounded who survive to come under hospital treatment, about 12 (12·33) may be expected to die; about 47 (46·75) to be cured, and to be discharged to duty; and about 21 (20·92) to be discharged as invalids from further service. It need hardly be observed, however, that if the conditions of warfare are altered, as they certainly will be in many respects in the future, important changes in the proportions just described may also be expected to occur.

Ultimate results of wounds on other occasions.—The final

disposal of the French wounded during the Crimean war cannot be given with the same precision, because the 'Guéris ou Evacués'—patients whose wounds had become healed, or who were discharged to be transferred to other hospitals—are counted together in the history; while no distinction is made in either case between those who did, and those who did not, return to duty. The same remark applies to the French Surgical History of the Italian War of 1859. It is to be presumed that Dr. Chenu could not obtain the necessary data to enable him to add to his admirable statistics of these wars the points of information under consideration.

With regard to the wars in which Great Britain has been engaged since the Crimean war, the information is only in part recorded. The History of the New Zealand War, previously alluded to, gives full particulars up to the time of the invaliding of the wounded men to England, but the final disposal of these invalids is not recorded in it. The same remarks are applicable to the account of the Ashanti war. The final disposal of the British troops wounded in the Indian Mutiny of 1857–59 is incomplete, for the records only show the disposal of those who were invalided home to England—the numbers of those who were wounded and died in hospitals in India, or who returned to duty in that country, have not been placed on record.

The absence of the information is not a matter of so much importance as regards the above-named wars in which British troops were engaged—the Indian Mutiny, New Zealand and Ashanti wars—on account of the nature of the weapons with which the enemies opposed to them were armed; but it is to be regretted that this information is not complete in respect to more recent European campaigns; for, if it had been, many of the statements which have been put forth regarding the surgical consequences of the successive changes made in the weapons of warfare during the last five-and-twenty years might have been subjected to more rigid tests, and a firmer foundation established on which to forecast the probable results to armies of the further advances in destructive power which have been lately applied to them. Whatever effects, however, may be in store for those who will be actively engaged in the wars of the future, the line of duty of the military surgeon remains unchanged. As hitherto, he ought to arm himself with all available knowledge that can be brought to bear on his calling, so that he may prove to be, on all occasions, the means of mitigating the ills and sufferings which the struggles of the combatants may produce, to the fullest extent that surgical science, combined with special devotion, can accomplish, and that thus, in person, he may always embody the true spirit of the red-cross motto—

INTER ARMA CARITAS.

APPENDIX

NOTES AND REFERENCES

Arranged and Numbered according to Sections

SECTION I

PRODUCTION OF GUNSHOT WOUNDS

Shot from air-guns, note 1, *p.* 2.

The late Mr. Syme described a case of gunshot wound of the foot from an air-gun, in which the ball lodged, and injured the metatarsal bone of the great toe. One of the chief points of interest in the case was 'that the effects of the shot so closely resembled those inflicted by the force of gunpowder.'—*Monthly Journal of Medical Science,* Edinburgh, March 1850, p. 244.

Wounds resembling gunshot wounds, note 2, *p.* 4.

Dr. Livingstone has remarked that a wound from the teeth of a lion has the same characters as a gunshot wound. In his 'Missionary Travels in South Africa,' 1858, he writes: 'Lions' teeth not only lacerate but crush the flesh as does a rifle bullet; and, as in the case of a gunshot wound, extensive sloughing follows.' The enormous muscular force, and the rapidity with which the teeth are forced through the flesh, especially when the animal is in a condition of rage, explain the effects Dr. L. has described in the foregoing passage, and which he unhappily experienced in his own person. These results undoubtedly bear a strong resemblance to those of many gunshot injuries, but the wounds themselves are obviously wanting in some of the features by which wounds from gunshot are usually characterised.

Size of gunpowder grains, note 3, *p.* 7.

Before rifled guns were introduced, gunpowder for large guns was known as L. G., or 'large grain,' to distinguish it from small-arm powder, which was known as F. G., or 'fine grain' powder. A powder of larger grain was subsequently introduced in 1860—R. L. G., or 'rifle large grain.' Its size was such as to be retained upon a sieve of eight meshes to the inch, and to pass through one of four. The grains are angular, highly glazed, and one pound contains 13,000 of them. As guns became larger, a larger grain was introduced. In 1867 'pellet' powder came into use. One of these grains,

or pellets, is a disc of about the size of a sixpence, with a depth of half-an-inch. Subsequently 'pebble' powder was introduced in 1869. In this powder the grains are more irregular in form, more compressed, and therefore of higher density. They resemble black pebbles of about half-an-inch in diameter, or of about the size of a common marble. The powder used in the experiments with the 81-ton gun has been angular in outline, and has varied in size from 2-inch cubes to $1\frac{1}{2}$-inch cubes. The black powder for rifled portable arms is of a size to be retained on a sieve having 20 meshes to the inch, and to pass through one having 12 meshes. The glazing of the grains of fine powder is produced by their being rubbed against each other in machines made for this purpose; the glazing of some of the large grain powder is assisted by the addition of plumbago.

Force exerted by exploded gunpowder, note 4, *p.* 8.

Bunsen and Schischkoff, experimenting upon one gramme (15·43 grains) of sporting powder, determined the amount of heat due to the actual combustion of the powder to be 619·5° C. (1115° F.), and calculated the temperature of the flame produced by the combustion to be 2993° C. (5419° F.). They also estimated the maximum pressure exerted by the gases at the first instant of evolution on the inner surface of the gun and on the projectile at 4374 atmospheres.—Quoted from Pogg. *Ann.*, c. ii. 321; Wagner's *Jahresb.* 1857, p. 131; 1858, p. 158. Art. 'Gunpowder' in Watts' 'Dictionary of Chemistry,' 1864.

Fulminating powder, note 5, *p.* 8.

The composition for the percussion caps used with English rifles contains fulminate of mercury, 4 parts; chlorate of potash, 6 parts; ground glass, 2 parts; the last being used to cause more friction among the particles. Sulphide of antimony is added in some compositions of a similar kind.

Gun-cotton, note 6, *p.* 9.

Army Circular, October 1870, Cl. 170.

Bombard, note 7, *p.* 16.

The word 'bombard' is not now in use as a substantive, though it is still retained as a verb, and in the artilleryman's title of 'bombardier.' The sound resulting from the discharge of the gun led to the origin of the name; 'bombus,' or 'bombardus,' being Latin for the blast of a trumpet.

Early use of guns, note 8, *p.* 16.

'It is affirmed that in this memorable battle' (battle of Crécy or Cressy, fought on August the 26th, 1346) 'the English began for the first time to use cannon, a thing yet unheard of in France. Four pieces, planted on a little hill, did great execution among the French troops, and struck them with such terror, that the success of this day is partly ascribed to the surprise of the French at this novelty.'—Rapin, translated by N. Tindal, 2nd edition, vol. i. p. 425.

Size of early guns, note 9, *p.* 16.

The size to which iron bombards were cast is shown by an accident which occurred in the year 1478. In this instance the projectile fired from the gun weighed 5 cwt.; and as the maker of the gun and a number of other persons were lowering a second projectile, the gunpowder suddenly exploded, casting out the ball, and at the same time bursting the piece. Sixteen persons are said to have been killed by the ball itself, and six others by fragments of the gun.

Projectile power attained in gunnery, note 10, *p.* 17.

See a lecture by Major Barker, R.A., in vol. 34 of the *Journal of the Royal U.S. Institution*, 1890, p. 257. The lecture is accompanied by a sketch of the trajectory of the shot alluded to in the text. The path of the projectile is contrasted with the height of Mont Blanc in the illustration, it having risen to a height of 5482 feet above that of the mountain.

Round shots or cannon balls, note 11, *p.* 18.

Balls, from βάλλω, to cast. Curiously, the terms in France for cannon balls and musket bullets are the reverse of the corresponding terms in English. *Boulets,* the diminutive of *boule* or *balle,* is used for cannon balls or gunshot; *balles,* for musket or pistol bullets.

Bolts, note 12, *p.* 18.

A very old designation of cannon-shot, used as early as the year 1413. It had been previously employed for arrows shot from cross-bows, and had the same derivation as the term 'ball.'

Shells, note 13, *p.* 21.

During the Franco-German war the Prussian field artillery consisted chiefly of breech-loaders, the French of muzzle-loaders. It has been asserted that the former had not only the military advantages of superior range and precision, but also that the shells used with them broke into a considerably greater number of fragments.

Artillery matériel, note 14, *p.* 24.

For the latest information on this subject, see 'Treatise on Ammunition,' 5th edition, corrected to March 1892; Lond., Harrison & Sons, 8vo, p. 582.

War-rocket composition, note 15, *p.* 29.

The composition contains the same ingredients as gunpowder, but they differ in their proportions. The proportions are saltpetre 64·75, sulphur 14·75, and alder charcoal 20·50 per cent. The charge is forced into the rocket under enormous pressure.

Fire of a Maxim automatic gun, note 16, *p.* 33.

The account given in the text is quoted from a report of the proceedings published in the *Times* newspaper.

Arquebus, note 17, *p.* 35.

The derivation usually given is *arc-à-bouche, i.e.*, bow with a mouth. That given by Ambrose Paré in the preface to the book *Des Playes faites par Harquebuses*, in the second edition of his complete works, published in 1579, is probably the correct derivation. His remarks translated are: '*Harquebuse* is a word taken from the Italians, because of the touch-hole by means of which the fire from the pan passes forward into the barrel of the gun, for the Italians call a hole *buzio;* and it is called *arc*, because it is now used as arcs (bows) were formerly used in war, the archers being then advanced in front, as the Harquebusiers now are, in battle.' In Latin works of the period the term *archibusum* was used; thus the title of the book published by Alfonsus Ferrius, at Rome, in 1552, was *De Sclopetorum, sive Archibusorum, Vulneribus.*

Stone bullets, note 18, *p.* 36.

In Gale's first chapter, which contains arguments apparently borrowed from Ambrose Paré against the prevailing notion of gunshot wounds being poisoned wounds, he does not refer to the effects of *leaden* shot being lodged in wounds, which he would probably have done had they been in common use. To prove that the shot does not become so hot during its flight as to form an eschar, or to burn the part wounded, he puts forth the following experiment—'Hange a bagge full of gonnepouder on a place convenient, and then stand so far off as your peece will shote leavell, and shute at the same, and you shall see the gonnepouder to bee no moore set on fyre with the heate of the stone, than if you caste a colde stone at it.' He makes only one allusion to a 'pellet of leade,' which he took out from a soldier who had been shot some time before at the siege of Pavia.

Pellet, note 19, *p.* 36.

This was one of the original names for a bullet, and was derived from the Latin *pila*, a ball. Gale in his treatises uses the words 'shotte' and 'pellets' indifferently: I have not met with the term 'bullet' in his writings. It is curious to observe how completely its use has disappeared in respect to leaden bullets, though boys still speak of the pellets of pop-guns. The pharmaceutical word 'pill' is evidently another form of the same term; as 'bolus' also appears to be an Anglicism of the Greek *βόλος*, a ball or shot.

Fusiliers, note 20, *p.* 36.

The three Fusilier regiments raised at this time were the 21st Fusiliers in 1670, the 7th Fusiliers in 1685, and the 23rd Fusiliers in 1688. The French word *fusil* seems to have been taken from the Italian *focile*, which means the piece of steel employed for striking flint and producing fire; as this, again, was derived from the Latin *foculus*, diminutive of *focus*, a fire-hearth.

Leaden bullets, note 21, *p*. 37.

Colonel Anderson, Superintendent of Machinery to the War Department, informed me that spherical bullets were first made by compression in the year 1840. Mr. David Napier was the inventor of the machine, and it was in use in the Royal Arsenal until about 1855. The lead was cast into rods about five feet long; these were held by hand to the compressing machine, and the projecting rim or 'frill,' formed at the junction of the dies, was afterwards removed by hand also. Elongated bullets were first made by compression in 1851. The lead was now squirted while solid into a long rod, and this was wound upon a reel like a rope. The end of this leaden rod was then given to a self-acting machine, which delivered the bullets complete without the need of any handling.

Foot-pounds, note 22, *p*. 44.

The term 'foot-pound' is used for the force required to raise a pound weight one foot from the ground, or, in other words, the force with which a pound weight falls to the ground by gravity from a height of one foot.

Maillechort, note 23, *p*. 51.

An alloy of zinc, nickel, and copper. The alloy called 'German silver' in England consists of the same three constituent metals, but their proportions are probably different in the two alloys.

Bullet of the Roumanian rifle, note 24, *p*. 51.

It consists of a core of hardened lead (pure lead 96 per cent., antimony 4 per cent.) pressed into a steel envelope, is ferruled, and covered with maillechort. See *Études Expérimentales sur l'Action du Projectile Cuirassé du Fusil Mannlicher, nouveau modèle Roumain. de* 6·5 *mm.*, par le Dr. Demosthen, Méd. de corps d'armée, Bucarest, 4to, 1894.

Rifles of 6·5 *mm. calibre, note* 25, *p*. 52.

A rifle of this calibre (0·2559 in.) is reported to be under consideration for adoption in the Netherlands army.

Weight of Chassepôt bullet, note 26, *p*. 53.

The weights really varied between 375 and 398 grains. One specimen, in the Military Surgical Museum at Netley, weighs 398 grains, another 396 grains, while several taken from cartridges during the Franco-German war weigh only 375 grains. A considerable collection of the rifle bullets used on both sides during the Franco-German war and extracted from wounds, may be seen in cases 582, 582*g*, 588*a*, and 588*b* in the Museum of Military Surgery at Netley.

Note 27, *p*. 54.

Gurlt, 'Military Surgery Fragments,' 1864.

Ashanti war, note 28, *p.* 58.

Army Medical Reports, vol. xv. p. 258. The troops left the Gold Coast in February 1874. The deaths enumerated are up to the 31st of May 1874.

Linked bullets, note 29, *p.* 60.

Specimens of linked bullets (case 579*b*, 632, &c.), and of many other unusual forms of projectiles, are preserved in the Museum of Military Surgery at Netley.

Treaty regarding explosive bullets, note 30, *p.* 62.

The following is the text of the convention of St. Petersburg relative to these projectiles. Its date is the 16th of November 1868.

'Considering—that the progress of civilisation ought to have the effect of lessening as much as possible the calamities of war;

'That the only legitimate object that States ought to propose to themselves during war is to weaken the military strength of their enemies;

'That, for this purpose, it is sufficient to put *hors-de-combat* the greatest number of men possible;

'That this end would be overpassed by the employment of arms which would uselessly aggravate the wounds of men placed *hors-de-combat*, or that would render their death inevitable;

'That the employment of such arms would be consequently contrary to the laws of humanity;

'The undersigned, having received the orders of their Governments in this respect, are authorised to declare as follows:

'§ 1. The contracting Powers mutually bind themselves to renounce, in case of war among themselves, the employment by their land or sea forces of all projectiles charged with explosive or inflammable matters, of a less weight than 400 grammes.

'§ 2. They will invite all the States which have not sent delegates to the military international commission at St. Petersburg, to accede to the present engagement.

'§ 3. This engagement is only obligatory upon the contracting or acceding parties, in case of war between two or more of themselves; it is not binding in regard to parties who have not joined the convention.

'§ 4. It will equally cease to be obligatory from the moment when, in a war between Powers which have joined the convention, another Power not a party to the convention shall join one of the belligerents.

'§ 5. The contracting and acceding parties will come to a further understanding among themselves, every time that a precise proposition shall be made on the subject, as regards future improvements that science may make in the arms of troops, so that the principles which they have laid down for reconciling the necessities of war with the laws of humanity may be maintained.'

Use of explosive bullets, note 31, *p.* 62.

Refer to the *Times* of the 9th of December 1868, the *Pall Mall Budget*, and other newspapers about the same date.

Explosive bullets, note 32, *p.* 63.

Specimens of the Metford, and a collection of other explosive rifle bullets, are preserved in the Museum of Military Surgery at Netley, in case No. 591.

U. S. Gardner explosive bullet, note 33, *p.* 64.

Op. cit., Part 3, chap. xii. p. 702. The specimen from which the drawing of the exploded bullet has been taken is No. 456 in the U. S. Army Medical Museum.

Small shot, note 34, *p.* 65.

The various kinds of shot used for fowling purposes are shown in 22 glass tubes in the Museum of Military Surgery at Netley. See case No. 594.

Projectile air in wounds, note 35, *p.* 70.

The case alluded to was described, in a work on 'Wounds of the Chest,' as a 'penetrating wound without injury to lung,' and was adduced to prove that a wound of the chest in which the lung is uninjured may be attended by traumatic emphysema. Mr. T. Holmes of St. George's Hospital, who attended the patient, informed me that the pleural cavity in the case was quite intact. See also Holmes's 'System of Surgery,' 3rd edit., vol. i. p. 521.

SECTION II

CAUSES WHICH INFLUENCE GUNSHOT INJURIES

Shapes of bullets, note 1, *p.* 74.

Preps. Nos. 2926B and 2926D. See Descriptive Catalogue of the Pathological Specimens in the Museum of the Royal College of Surgeons of England, pp. 92, 93.

Deformed bullets, note 2, *p.* 78.

The Museum of Military Surgery at Netley contains many examples of the strange shapes presented by deformed bullets extracted from wounds. Admirable drawings of such bullets may be seen in the beautiful atlas of plates accompanying Dr. Chenu's 'Med. Chir. Statistics of the Campaign of Italy in 1859-60.'

Lorenz steel-armoured bullets, note 3, *p.* 81.

Ueber die Wirkung Moderner Gewehrprojectile insbesondere der Lorenz'schen verschmolzenen panzer-geschosse auf den Thierischen Körper, von Dr. B. von Beck, Generalarzt des xiv armee corps; Leipzig, Von Vogel, 1885.

Muzzle velocity of M.-H. bullet, note 4, *p.* 82.

See 'Treatise on Military Small Arms,' p. 19.

Volumes of bullets, note 5, *p.* 85.

Weights and volumetric measurements taken in the Laboratory of the Army Medical School in March 1892.

Russian bullets, note 6, *p.* 88.

The heaviest Russian bullet, from the Crimea, in the collection of the Army Medical Museum at Netley, is a solid, ogival-topped rifle bullet with two cannelures, weighing 772 grains.

Minié rifle bullet, note 7, *p.* 89.

The large size and weight of this projectile seem to have been due to the influence of the Duke of Wellington. It is stated in his Life by G. R. Gleig, Chaplain-General (London, 1864, p. 397), that when the 'Minié' musket was introduced, 'the one point to which the Duke adhered was, that the old bore should be retained: partly because the greater size of the English bullet had rendered it more effective than any other in former wars; partly because, in the event of the stock of conical bullets running short, the troops, in case of emergency, would be able to use the musket cartridges which were already in store.' The Duke also had a suspicion that the rifle might not answer in the hands of our troops as well as the musket had done.

Bullet impressed by canvas, note 8, *p.* 91.

The bullet figured in the text has been deposited in the Museum of the School of Musketry.

Velocity and kinetic energy of bullets in motion, note 9, *p.* 97.

The term velocity as applied to a shot in transit signifies the rate of its movement in a given space of time, and is usually in England expressed by the number of feet through which it would travel in a second of time, supposing its movement to be uniform. Thus if the initial velocity of a bullet is stated to be 2000 feet in a second, what is implied is that if the same rapidity of movement that it has at the given instant of quitting the muzzle of the weapon were continued in air for one second of time, the distance it would travel in that second would be 2000 feet.

The quantity of motion in a moving shot is spoken of as its momentum, and is represented by the product of its mass multiplied by its velocity. If two shot are travelling at the same rate of speed, but the mass of one as represented by its weight is double that of the other, then the momentum of the heavier bullet is double that of the lighter bullet. Or if two shot of equal weight are moving at the same time, but the velocity of one is double that of the other, then equally the momentum of the faster bullet would be double that of the slower bullet. The ordinary symbol for momentum is MV, in which M stands for mass, and V for velocity.

The kinetic energy, *vis vivâ*, or mechanical power of a projectile increases as the square of the velocity; it is expressed by MV^2. Or as the *weight* of a projectile is really its mass multiplied by the force of gravity, so its *mass* is its weight divided by the force of gravity; $\frac{W}{g}$, in which g stands for gravity, may therefore be substituted for M. So the formula for ascertaining the *vis vivâ* of a projectile may be $\frac{WV^2}{g}$. This will represent the mechanical power of a bullet in motion, or, as it were, the force contained in it, and consequently the amount of damage capable of being done by it, relatively to other bullets.

When a bullet in its flight strikes a body, it has a certain amount of *vis vivâ* = $\frac{WV^2}{g}$ at the instant of striking. Supposing the projectile penetrates and comes to a stop, or lodges, in that body, it has expended its kinetic energy in accomplishing this result. As it commenced its penetration with an energy = $\frac{WV^2}{g}$, and finished its course with none remaining, or O, the mean of these two conditions is taken to express the quantity of energy expended, or the work done, viz., $\frac{WV^2}{2g}$. This formula then expresses the force expended by the projectile in overcoming the resistance opposed to it in penetrating and effecting its lodgment. It does not follow that this formula will express its power of penetration, or *penetrative energy*, as compared with other bullets of the same weight and armed with the same velocity; for in estimating power of penetration certain physical conditions have to be taken into account, such as the figure, dimensions, hardness, &c., of projectiles.

Muzzle velocity of bullets, note 10, *p.* 99.

Lecture on 'Magazine Rifles,' by Captain James, late R.E., *Royal U. S. Institution Journal*, June 1892.

Velocity and mechanical power, note 11, *p.* 101.

'Treatise on Military Small Arms and Ammunition,' compiled at the School of Musketry, 1888.

Effects of velocity of bullets, note 12, *p.* 102.

John Hunter's Works. Part iv. of 'Gunshot Wounds,' chap. i., § 1, par. 5.

Primary healing of bullet wounds, note 13, *p.* 103.

After the remarks in the text on this subject were written, Professor Esmarch was kind enough to send me his essay, entitled *Die antiseptische Wundbehandlung in der Kriegschirurgie.* In this paper, Dr. Esmarch speaks of most severe gunshot wounds healing by simple primary union, without any suppuration, before the introduction of Lister's antiseptic treatment. He refers to such wounds as severe gunshot fractures of the thigh and perforating wounds of joints healing like subcutaneous wounds, without suppuration ('ohne Eiterung, wie subcutane Wunden'), not only in his own experience, but also in the experience of many other eminent German surgeons. In some portions of the remarks, however, similar cases are referred to as having healed almost without suppuration ('fast ohne Eiterung'), and it seems doubtful whether this qualifying expression may not have been applicable to all the cases referred to. If, however, the observations regarding the grave and complicated wounds mentioned as having healed without any suppuration are to be taken literally, I can only regard them as very exceptional cases.

Terminal velocity, note 14, *p.* 106.

Under the circumstances described in the text, a bullet, in ascending, has to overcome the attraction of gravitation, together with the resistance

of the air; in descending from its point of momentary rest, it is drawn downwards, and its speed accelerated, by the influence of gravitation. But, while descending, the air still acts as an opponent to its downward progress, and, according to experts in ballistics, it so acts that at a certain point in the descent the velocity attainable by the falling projectile through gravitation is balanced by it. From this point no further acceleration takes place, and if the remainder of the column of air were equally dense throughout, the velocity of the bullet for the rest of its fall would be at a uniform rate. The velocity which has been acquired by the falling bullet at the time of its reaching the point where its velocity is counterbalanced by the resistance of the air is described as its *terminal velocity.*

Spent shot, note 15, *p.* 107.

A private of the 20th Regiment was admitted as an invalid into Fort Pitt in September 1859. He had been struck a year before, near Lucknow, by a spent gunshot, about 2 inches above the external malleolus of the right leg. Simple fracture of both the fibula and tibia resulted. Union of the two bones was completed without sloughing or ulceration of the soft parts. The soldier was discharged from further service on account of impaired marching power, owing to deformity which had been allowed to occur during the process of repair.

Spent shot, note 16, *p.* 108.

La Guerre de Crimée, par L. Baudens, 1858, p. 124.

Effects of rotation on penetration, note 17, *p.* 111.

One of the most remarkable instances that I am acquainted with of a spherical bullet being deflected by a yielding surface is the following, which was related to me by my friend Colonel Onslow. One day, about the year 1833, when the 54th Foot, under Colonel Mildmay Fane, were assembling for parade at Trichinopoly, a soldier stepped up to Lieut.-Colonel Reed, the second in command, and made a request to him. This officer was on horseback, and had in his hand a ratan cane, about the thickness of a little finger, which he was moving up and down in front of his face. Colonel Reed's reply to the man was to the effect that he ought to make his request through the captain of his company. The soldier, remarking, 'Oh! that's it, is it?' immediately levelled his musket at Colonel Reed and fired. The bullet happened to strike the cane in front of his face, ran up it, and was thus diverted from hitting its intended object. Colonel Reed's life was saved by this slight obstacle, for the shot was in a direct line for his head. The soldier was condemned to death, and was executed. Colonel Onslow, who was on the man's court-martial, informed me that the cane retained the mark where the bullet had struck it, from which point it was split up to the top.

Rotation of rifle projectiles, note 18, *p.* 112.

Major Owen, Professor of Artillery at the Royal Military Academy, Woolwich, states in the course of some remarks on the motion of projectiles: 'There is no doubt but that the rotatory motion of a projectile fired from a rifled gun greatly increases the penetration;' and again, 'Velocity of rotation increases penetration.'—*Royal United Service Institution Journal*, vol. vi. pp. 231–233.

Effect of rotation after entering the body, note 19, *p.* 113.

An officer of the 33rd Regiment was wounded in the trenches before Sebastopol, in the abdomen. There was an opening of exit in the back at a point precisely opposite to the abdominal opening in front. He was told his wound was a mortal one, but he had an instinctive conviction from the first that it was not, and so he maintained. The subsequent progress of the case proved the patient's diagnosis to be correct, and the surgeon's wrong. The bullet had not penetrated the cavity, but had coursed round it outside.

Rotation of spherical bullets, note 20, *p.* 115.

Percy, Dupuytren, Baudens, and others refer the conical shapes of bullet tracks to the special cause named in the text. Baudens gives the same explanation as Percy : 'The bottom of the wound is larger than the wound of entrance, owing to the persistence of the movement of rotation, which lasts longer than the movement of projection.'—*Clinique des Plaies d'Armes à Feu,* par M. L. Baudens, &c., Paris, 1836, p. 17.

Lead melting from quickness of flight, note 21, *p.* 119.

'Stridentem fundam, positis Mezentius hastis,
Ipse ter adductâ circum caput egit habenâ,
Et media adversi *liquefacto* tempora plumbo
Diffidit, ac multâ porrectum extendit arenâ.'
Virgilii *Æneidos*, lib. ix. l. 586–589.

'Balearica plumbum
Funda jacit, volat illud et incandescit eundo,
Et quos non habuit, sub nubibus invenit ignes.'
Ovid, *Met.*, ii. 730–732.

Baron Percy also quotes the following passage from Lucretius (lib. vi.), in illustration of the fact that the Roman slingers used leaden bullets in their slings, and that they threw them with such force as to cause the lead to be sometimes melted owing to its rapid flight through the air :—

'Plumbea verò
Glans etiam in longo cursu volvenda liquescit.'
Manuel du Chirurgien d'Armée, par M. Percy,
Paris, 1792, p. 15.

Heat of bullets, note 22, *p.* 119.

Gale argues the point in the following terms: 'But that you shall perfectlye understande and be judge your selfe in this case. Hange a bagge full of gonnepouder on a place convenient, and then stand so far off as your peece will shote leavell, and shute at the same, and you shall see the gonnepouder to bee no moore set on fyre with the heate of the stone, than if you caste a colde stone at it.'—Gale, op. cit., p. 6. It is curious that a namesake of Gale has in our own time lessened the value of this proof by showing that although the gunpowder is not fired, it is not a complete proof that it results from the shot being destitute of heat; for Mr. Gale has put even red-hot iron into gunpowder without it being 'set on fyre.'

Bullets fired into gunpowder, note 23, *p.* 119.

The gunpowder used by Dr. Schadël was the small grain powder ordinarily used with fowling-pieces; the powder used by Paré and Gale was probably similar to what is now called 'mealed powder.' Although such yielding and mobile powders are not exploded by the impact of a bullet even when possessing a high degree of energy, trials have shown that the larger forms of gunpowder, such as prism powder, can be fired by the impact of a bullet having a striking velocity of a little over 600 ft.-secs. ('Treatise on Ammunition,' 1892, p. 10). This effect is doubtless due to the resistance of the solid compressed gunpowder to the action of the bullet. Many accidents have shown that gunpowder can be exploded either by friction or a blow under special circumstances, and hence the precautions taken in dealing with powder magazines are quite necessary.

Heat of projectiles, note 24, *p.* 120.

By Dr. Hagenbach's calculation, the impetus of the ball $\frac{MV^2}{2}$ was equal to 209 kilogrammetres, and its mechanical equivalent of heat 0·49 thermal unit. The entire projectile (40 grammes) had to be raised to near the temperature of the melting-point of lead, and the 27 grammes (only 13 grammes being unmelted) had to be melted. Assuming 100° C. as the initial temperature of the bullet, which was somewhat warmed by the heat of combustion and friction, the melting-point of lead being 335° C., its specific heat 0·031, and its latent heat of fusion 5·37, he finds necessary for heating 0·29 thermal unit, and for fusion 0·15; giving a total of 0·44 thermal unit, this being only ·05 less than the estimated mechanical equivalent (see Poggendorf's *Annalen der Physik und Chemie*,' Band 140, p. 486, 1870). In a subsequent volume of the same journal (Band 141, p. 594, 1871) Mr. J. Bodynski criticises Dr. Hagenbach's calculation, and shows that the impetus $\frac{MV^2}{2}$ was really equal not to 209, but to 2048 kilogrammetres, and that consequently, 424 kilogrammetres being equal to 1 heat unit, the total heat developed would be 4·83 heat units. But 4·83 heat units, if wholly expended in melting lead, would suffice to melt 381 grammes, not 27 grammes: the excess of heat, however, is expended in the manner quoted in the text.

Effects of pressure on heated bullets, note 25, *p.* 123.

See experimental specs. in cases $\frac{618}{10}$ and $\frac{618}{11}$ in Museum of Military Surgery at Netley.

Poison of gunshot wounds, note 26, *p.* 124.

Paré gives the following account of the occurrence referred to in the text. He had gone into Sardinia in 1536, as surgeon of General Montejan, who held a command in the army of Francis the First of France. When alluding to an engagement in which there were many men wounded by bullets on both sides, he writes: 'I will tell the truth, I was not very expert at that time in matters of chirurgery; neither was I used to dress wounds made by gunshot. Now I had read in John de Vigo, that wounds made by gunshot were venenate, or poisoned, and that by reason of the gunpowder; wherefore for their cure, it was expedient to burn them with oil of elders, scalding hot, with a little treacle mixed therewith. However, as I gave no great credit to the author or his remedy, from knowing that caustics could not be

poured into wounds without excessive pain, I determined before I would run any risk to see whether the surgeons who were with me in the army used any other kind of dressing to these wounds. I observed that all of them used the method of dressing prescribed by Vigo, and that they filled, as full as they could, the gunshot wounds with tents and pledgets dipped in this scalding oil at the first dressing, which encouraged me to do the same to those who came to me to be dressed. It chanced on a time that, by reason of the multitude who were hurt, I was in want of this oil. Now because there were some few left to be dressed, I was forced, that I might not seem to be without anything needful, and that I might not leave them undressed, to apply a digestive made of the yolk of an egg, oil of roses, and turpentine. I could not sleep all that night, for I was troubled in mind; the dressing of the preceding day (which I judged unfit) disturbed my thoughts; and I feared that the next day I should find those whom I had not dressed with scalding oil dead, or at the point of death, from the poison of their wounds. I therefore rose early in the morning, visited my patients, and, contrary to expectation, I then found such as I had dressed with a digestive only free from excessive pain, that they had had good rest, and that their wounds were not inflamed nor tumefied; while, on the contrary, the others that were burned with the scalding oil were feverish, tormented with much pain, and the parts around their wounds were swollen. When I had tried this many times in others, I thought thus much—that neither I nor any other ought ever to cauterise wounds made by gunshot.'

Dailly, note 27, *p.* 125.

The title of Dailly's work referred to is—*Traité des Blessures et Playes faites par Armes à Feu, vulgairement dites Playes d'Arquebusades. Auquel sont amplement expliquées leur Nature et Curation avec la Manière de Corriger les Accidents qui les Accompagnent, le tout avec Méthode.* Mis en François par Pierre Dailly, Maistre Chirurgien Juré à Paris. À Paris, chez André Boutonné, au Palais, vis-à-vis la Sainte Chapelle, à la belle estoille, 1668. The work is divided into thirty-five chapters. The first chapter, *De la Nature et Essence des Playes d'Arquebusades*, and the seventh chapter, *Ou l'on détruit l'Opinion de ceux qui rejettent la Qualité veneneuse des Playes d'Arquebusades*, contain the arguments adduced by the author to show that gunshot wounds are poisoned wounds. There is a good copy of Dailly's work in the British Museum Library. The name of the author is given in the catalogue as D'Ailly, but Dailly is the correct name, as shown at the end of the prefatory epistle, and also in the *Extrait du Privilège du Roy*. The first two letters are accidentally separated in the title-page of the book, but there is no apostrophe between them.

Poisoned bullets, note 28, *p.* 125.

Des Plaies d'Armes à Feu; Communications faites à l'Académie Nat. de Médecine, Paris, 1849, p. 9.

Note 29, *p.* 126.—Op. cit. supra, p. 83.

Note 30, *p.* 127.—Clowes, to determine whether 'the flame of the fire out of the peece doth extinguish and kill the force and strength of any poisoned shot,' got the master-gunner at Portsmouth to let one of the soldiers fire an arrow out of a musquet. The soldier, 'taking his rest' at 200 paces, caused the arrow to stick deeply in the post of a gate, when, it was found, 'not one feather was touched with flame or fire.' Clowes relates that he had 'since seen the like done with our common sheafe arrows in a caliver,' and concludes that 'this proveth the fire cannot burn out the

impression of a poisoned bullet.' (The question of the power of the flame in a fire-arm to sterilise a bullet fired from it has not been left unconsidered in our own day.)

Among the cases of gunshot wounds recorded by Clowes is one of an officer who was wounded in the right natis by a musket bullet. The missile lodged, and was followed by great œdema, pain, general anxiety, &c. Clowes consults a physician in the case, whose advice is 'To make deepe incision, and then with a pair of tenacles to take hold of the bullet and to bring it out so easily as may be; then to scarifie well the lips or sides of the wound, which done, yee shall presently set on a strong cupping glasse or a flame of fire, that yee may the better evacuate and draw out the venomous and poisoned blood which lurketh deeply in the bottom of the wound.' Clowes mentions that he treated the case according to this advice, and the patient recovered. He notices that, on extracting the bullet, he found it strangely indented and marked with unusual colours, which colours, on the lead being melted, went away. It is curious to observe, when a preconceived opinion prevails, what ordinary circumstances are turned to its support. The case quoted is headed, 'Cure of a Lieutenant which was shot in the Right Buttock with a Poisoned Bullet.' See Clowes' Works, edition 1596, pp. 44–50.

SECTION III

CHARACTERISTIC FEATURES OF GUNSHOT INJURIES

Angle of impact, note 1, *p.* 132.

Sir Gilbert Blane, in his account 'Of the Wounds received in the Actions of April 1782' ('On the Dis. of Seamen,' 3rd edition, 1803, p. 575), refers to two instances of a ball passing close to the stomach and producing instant death, life being destroyed, 'without any visible external injury or breach of the parts, nor any appearance of the body from whence the injury proceeded.' Mr. Ellis (op. cit. infra) refers to the case of Captain M. of the Bengal Native Infantry, who, while serving in Lord Lake's army, lost the sight of both eyes by the passage of a cannon ball across his face, which inflicted no external mark of injury; also, to the case of an officer in the trenches at the siege of Bergen-op-Zoom, who, while in the act of stooping to assist a soldier who had fallen, lost instantaneously the sight of one eye, and gradually that of the other, in consequence of a cannon ball passing across his face without touching it.

Injuries attributed to windage of shot, note 2, *p.* 134.

J. Brown, surgeon to Charles II., afforded an example in his own person of an erroneous impression, such as is described in the text. He had his arm broken by a cannon-shot, and attributed the injury to the effects of windage. He writes: 'The which I am sufficiently satisfied in, having been made an example of the same in the Dutch wars by the wind of a 24-pound bullet, by which my arm was miserably fractured and contused.'—See chap. xviii. of 'A Compleat Discourse of Wounds both in General and Particular, &c.,' by John Brown, Sworn Chirurgeon in Ordinary to the King's most Excellent Majesty, London, 1678.

Injuries from windage, note 3, *p.* 134.

I have found the notion that the 'wind of shot' could produce injuries in some of the earliest writings on gunshot wounds. In the work of Alf. Ferrius, *De Sclopetorum sive Archibusorum Vulneribus*, published at Rome in 1552, and in the 18th chapter of the 2nd book, *De Majorum Bellicorum Fulminum Contusionibus*, there occurs the following passage: 'Fieri enim forte fortunâ potest, ut non semper interimant, sed contundant tantum, vel ictu, vel etiam *spiritu*,' &c.

Light substances carried by shot, note 4, *p.* 134.

Dr. Spence observes in his remarks on this subject: 'I know an officer who had considerable pain in the loins for some time after a battle, supposed to be from the wind of a shot, as he was not conscious of anything having hit him, and there was no external mark; but the flakes of a bed from the hammock-knittings being pretty thick on his coat, showed to me that the pain was produced by something more dense than wind. As to the fact of cannon balls carrying light substances with them, they so very seldom stick in the body, I have had no opportunity to ascertain positively that they do; but with grape-shot, canister-shot, and musket balls, I have had ample testimony; and I think there is every reason to believe that cannon balls do also, from the many pieces carried away where the shot have hit or passed through; and it is also pretty evident on sweeping the decks after a battle.'—'Observations on those Accidents commonly ascribed to the Wind of a Ball.' G. T. Spence, M.D., Surgeon R.N., in the *Edinburgh Medical and Surgical Journal*, vol. viii. p. 161.

Electricity supposed to accompany shot, note 5, *p.* 134.

See 'Observations on the Nature and Cause of certain Accidents which sometimes occur in Battle, and have been usually ascribed to the Wind of a Ball,' by Mr. Ellis, in the *Edinburgh Medical and Surgical Journal* for January 1812.

Combatants and windage of shot, note 6, *p.* 134.

Frequent reference to injuries from windage is made in military writings. The following quotation is illustrative of the belief in them which is still impressed on the minds of combatants: 'I pushed on, and reached the point of my destination in safety; but galloping back, I felt a stunning blow across the spine, and at the same moment my horse rolled over with me. I was confident the animal had been struck by a cannon ball; but, to my great surprise, I was not able to discover any wound. As I was myself unhurt, I remounted my brave animal and continued my way. A solid shot had passed close to my horse's back, and the current of air set in motion by its passage had knocked over both horse and rider. Afterwards, during the war, I witnessed many similar cases of prostration of men and animals by windage.'—'Memoirs of the Confederate War of Independence,' by Heros von Borcke, chief of the staff to General J. E. B. Stuart, *Blackwood's Edinburgh Magazine*, vol. xcviii., October 1865, p. 392.

Near passage of shot without hurt from windage, note 7, *p.* 134.

Mr. Bransby Cooper used to relate an instance which came under his own observation of the little effect produced by the 'wind of a ball.' When he

was an assistant-surgeon of the Royal Artillery, and on duty near Bayonne, he saw a 32-pounder shot pass between the outstretched thighs of an artillery officer at the time he was sighting a gun. It caught and carried off the tail of his uniform coat, but did no further injury whatever. Mr. Cooper's faith in the wind of a shot having any power to hurt a person was shaken from the date of this occurrence.

Ear removed by shot and no hurt from windage, note 8, *p.* 135.

In the *Edinburgh Medical Journal* of 1890, pp. 685–88, will be found some interesting communications from the late Dr. Pagan of Edinburgh to myself. At the battle of Waterloo, Dr. Pagan, then a lieutenant of the 55th Regiment, had the external portion of one of his ears torn away by a ricochet cannon-shot which killed several men and officers near to him. In the latter days of his life Dr. Pagan informed me that he heard better on the side which had been rased by this massive projectile than he did on the opposite side, which had been untouched. The auditory nerve on the wounded side had not been affected, notwithstanding the close proximity of the passing gunshot.

Although ingenious applications of photographic science have rendered visible the waves of air set in movement by a bullet in its flight, I know from experience in my own person that, at a distance as near as possible without contact, the disturbance of the air particles conveys no sensation to the surface of the face. The passage of a bullet that passed close to my cheek at the battle of the Alma and struck an officer directly behind me was only known to me by the sound which accompanied it in its flight.

Windage of shot disproved by experiment, note 9, *p.* 135.

Delorme, in his *Chirurgie de Guerre*, p. 474, refers to Paré, Bilguer, the surgeon-in-chief under Frederick the Great, Tissot, Boucher, Ravaton, Hevin, Dufouart, among writers on gunshot wounds, who have defended the doctrine of the action of the *vent de boulet*. Tissot calculated the impulsive energy of the air displaced by a cannon-shot. A Russian military surgeon, Pelikan, however, disproved by experiment the exertion of this alleged impulsive force. He so arranged a cylinder and piston capable of registering a pressure of 1½ lb., that it occupied a distance of 3 inches from some massive shot which passed by it in succession at a speed of over 950 feet in a second. Despite the closeness of the piston to the line of flight of the shot, it remained unmoved.—*Recherches Expérimentales sur les Contusions produites par le Vent du Boulet.* Pelikan. *Comptes rendus de l'Académie des Sciences,* t. xlv. p. 802.

Elasticity of skin, note 10, *p.* 138.

A full report of this case may be seen in the *British Medical Journal* of August 20, 1870.

States of bones divided by massive gunshot at high speed, note 11, *p.* 141.

At the battle of Inkerman a heavy round shot struck the sergeant-major of the regiment with which I was serving, and subsequently the captain of the grenadier company, who was standing a little distance behind him. The limb of the sergeant-major was carried completely away from a little above the knee, and an amputation higher up had to be performed in

order to get suitable covering for the stump. In the instance of Captain K., the leg was not taken completely off, but it was only hanging by the skin of the back of the popliteal space, on which the bones forming the knee-joint were lying pulverised. On the occasion of the final assault of Sebastopol, three men of the 19th Regiment were moving along one of the trenches close to one another, when a heavy projectile, sweeping along, carried off the right arms of the first and second men in advance, and smashed the right arm of the third man behind. Amputation was required in the first two instances only to get coverings for the stumps; in the third, to remove the parts which had been shattered. Among the large coloured drawings by Sir Charles Bell at Netley are three of soldiers whose arms had been completely carried away, in two instances by cannon balls, in the third by a howitzer shell, at the battle of Waterloo The head of the humerus is shown in one case remaining entire in the socket without fissures, while the surface of the soft parts left by the shot is very nearly level.

Instances of rifle bullets at muzzle speed failing to perforate the cranium, note 12, *p.* 144.

The following are short descriptions of the preparations representing the three cases of suicide alluded to in the text, in each of which a rifle bullet was fired, with a full charge of powder, directly into the head, without effecting a passage through it.

1. No. 606A, Museum of Military Surgery, Netley—case containing twelve fragments of a leaden bullet and wooden plug, together with the remains of the Snider-Enfield cartridge out of which the bullet was fired. No. 485, App. Pathological Museum, Netley—fractured bones of cranium, and upper five cervical vertebræ, articulated as far as practicable, together with broken remains of facial bones strung on wire. From Private J. P., 1st Battalion, 11th Regiment, who committed suicide at Morar, Central India, in July 1872, by placing the muzzle of a breech-loading Enfield rifle in his mouth and pulling the trigger with his foot. The scalp was not perforated. The skull could be felt to be shattered on pressing the scalp. On examination, the tongue presented a V-shaped laceration and was much charred. Several of the cervical vertebræ were fractured, the atlas and axis being partly pulverised. Nearly all the bones of the face and cranium were more or less shattered. In some places brain substance was forced between the clefts of the broken bones. Brain mashed up, and detached pieces of bone in it. The wooden plug of the bullet was found in the substance of the trapezius m. on a line with the broken axis. The clay plug was not discovered. The history of the case, and the preparations which accompanied it, were presented by Staff Assistant-Surgeon J. B. Wilson, M.D.

2. No. 605, Museum of Military Surgery—case containing nine fragments, of different sizes, all more or less flattened and distorted, of a Snider-Enfield bullet, and the wooden plug, together with the cartridge case removed from the rifle. Private W. W., æt. 21, 1st Battalion, Coldstream Guards, committed suicide at Brompton barracks, on January 28, 1872. These specimens, with a history of the case, were forwarded by Staff Assistant-Surgeon Allen, M.D., who made the post-mortem examination. The man had placed the muzzle of his rifle under his chin, and discharged its contents by means of a piece of braid attached to the trigger. The scalp was found to be entire. There were two projections over the occipital bone, one on each side of the occipital protuberance. One appeared to be the conical bullet, but on inspection was found to consist of pulverised bone, which a portion of the bullet had driven out through a clean circular aperture. The other projection was caused by some fragments of the bullet. All the larger cranial bones were separated at their sutures; fragments of lead were scattered among them.

3. No. 605A, Museum of Military Surgery—greatly distorted Snider-Enfield rifle bullet and wooden plug, removed from the posterior lobe of the left hemisphere of the brain of Private R. S., 2–16th Regiment. Presented by Surgeon R. M. Bradford, who made the post-mortem examination. The man was found dead on the floor of his hut on the 8th December 1869, with his rifle between his knees, and the boot and stocking removed from his left foot. There was a small circular hole, with slightly inverted edges, beneath his chin, and the surrounding skin for more than an inch in every direction was blackened and burned. No orifice detected by which the bullet could have escaped. Large quantity of blood about the ears and nose. On removing the scalp, the vault of the cranium was found broken into many irregular pieces. Great extravasation of blood between the skull and surface of the brain. Brain entirely broken up, blackened, with strong odour of exploded gunpowder, and containing many small fragments of bone. On removing the brain the bullet fell out on the table. It was flattened into an irregular crescentic shape, much indented, and from its position seemed to have been stopped and altered in shape by the occipital bone, which, however, was not itself broken. The base of the skull was shattered into a multitude of fragments, none of the bones being distinguishable. The rifle used was the Snider-Enfield, with the regulation cartridge.

Enlargement of exit wound of bullet, note 13, *p.* 148.

Preparation No. 510, Pathological Museum, Netley.

Fatal wound of President Lincoln, note 14, *p.* 153.

Observations on special features of this wound will be found in the 'Surgical History of the U. S. War of the Rebellion,' Part i., 'Wounds of the Head,' p. 306. See also the *Lancet*, vol. i., 1865, p. 649.

Bone fractures by small-bore bullets, note 14*, *p.* 159.

The principal works in which drawings and photographic plates to illustrate the effects of small-bore rifle bullets fired against bones at different distances may be seen, are the following:—

Études Experimentales sur l'Action du Projectile Cuirassé du Fusil Mannlicher, nouveau modèle Roumain. de 6·5 *mm.*, par le Dr. A. Demosthen, &c., Bucarest, F. Göbl Fils, 1894. Captain Lagarde, 'Report of a Series of Expts. conducted at Frankfort Arsenal, in connection with the Ordnance Dept. of the U. S. Army,' printed in the Report of the Surgeon-General of the Army to the Secretary for War, for the fiscal year 1893, Washington, Government Printing Office, 1893, p. 73 to p. 95. Habart, *Die Geschoss-wirkung der* 8 *mm. Handfeuerwaffen an Meuschen und Pferden*, 1892. General-Stabsarzt Prof. Dr. von Coler, und Stabsarzt Dr. Scherning, *Ueber die Wirkung und die Kriegschirurgische Bedentung der neuen Handfeuerwaffen;* Atlas; 17 Tafeln en Photogravüre; Berlin, Hirschwald, 1894.

Rasing shot, note 15, *p.* 110.

From the French *raser*, to shave. 'La balle lui rasa le bras:' 'the bullet scored his arm.' It is in common use as a military term; thus, *Rasing fire*, the fire from the *rasant* flank of a bastion. It is sometimes written 'grazing,' but is properly as above.

Wound from a descending ricochet bullet, note 16, *p.* 162.

Captain G. Egerton, D.I.M., in the course of a lecture on Rifle Ranges, in February 1892, mentioned a case in which a bullet ricochetted from the ground and mounted very high into the air. In descending it wounded a marker in the head. The man was sitting on the ground with his back against a 30-ft. wall just to the left of the target which was being fired at.

Gaseous projectiles, note 17, *p.* 169.

'Erichsen's Surgery,' 6th edition, vol. i. p. 162.

Gaseous projectiles, note 18, *p.* 169.

Army Medical Reports, vol. viii. p. 521.

Note 19, *p.* 171.—'Surgical History of the Crimean War,' p. 310.

Note 20, *p.* 171.—'Notes of an Ambulance Surgeon,' by Sir William MacCormac, London, 1871, p. 49.

Note 21, *p.* 171.—'Dr. Roberts' Report of the 4th Divn., &c.'—*Med. Times and Gazette*, February 23, 1856, p. 184.

Magazine Explosions, note 22, *p.* 172.

Campagne d'Orient en 1854–56, par J. C. Chenu, &c., &c., Paris, 1865, p. 118.

Note 23, *p.* 172.—The quantity of gunpowder exploded, and the number of casualties on the French side, were given at much higher figures at the time of the occurrence of the accident. Mr. Russell states in his 'Diary' that the quantity of gunpowder blown up in the French Parc de Siège was: Russian powder, about 1700 barrels: French powder, about 800 barrels; or a total of about 250,000 lbs., irrespective of that contained in shells, rockets, and small-arm ammunition. He also relates that the French had 6 officers killed and 13 wounded; 65 men, chiefly artillerymen, killed, and 170 wounded. The effects of this explosion are very graphically described by Mr. Russell (see 'The War, from the Death of Lord Raglan to the Evacuation of the Crimea,' by W. H. Russell, London, 1856, p. 350, &c.).

Note 24, *p.* 172.—See Genl. Codrington's Despatch to Lord Panmure, dated November 17, 1855, and Adjt.-Genl. Pakenham's Returns enclosed. The force of the atmospheric wave from the explosion is well illustrated by the fact incidentally mentioned by Genl. Codrington, that windows were burst open and broken at the farm-house where the headquarters were established. This building was distant two and a half miles from the place where the explosion occurred.

Slit-like tracks of bullets, note 25, *p.* 179.

Legouest, *Traité de Chirurgie d'Armée,* Paris, 1863, p. 339.

Removal of substance in bullet tracks, note 26, *p.* 184.

'A Treatise on Gunshot Wounds,' by G. T. Guthrie, &c., London, 1820, p. 27.

Tracks left by explosive bullets, note 27, *p.* 188.

Relation Méd. Chir. de la Campagne d'Orient, par le Dr. J. Scrive, Médecin-en-chef de l'Armée, &c., Paris, 1857, p. 438.

American explosive bullets, note 28, *p.* 188.

Specimens Nos. 4601 and 4621 in the Washington Museum.

Fire of explosive bullets, note 29, *p.* 188.

'Memoirs of the Confederate War of Independence,' by Heros von Borcke, Chief of Staff to Genl. Stuart, in *Blackwood's Magazine* for Oct. 1865, p. 406.

Supposed shell bullet from wound of thigh, note 30, *p.* 189.

Specimen No. 4561 in the Washington Museum is the explosive projectile referred to. It is labelled, 'A conoidal bullet, considered to be a specimen of the explosive ball.' Fig. 30 is copied from a drawing of this specimen. I have frequently seen a conoidal bullet, with an iron culot, assume a similar shape when it has happened that the iron cup (not a very rare occurrence with the Minié bullet) had been driven through the projectile at the time of its discharge from the rifle.

Fosbery's shell bullets, note 31, *p.* 189.

See the 'Journal of the Royal U. S. Institution,' vol. xii., London, 1869, p. 16, art. 'Explosive Bullets and their Application to Military Purposes.'

Wounds from explosive bullets in India, note 32, *p.* 189.

See a letter in the *Times* signed 'Marksman,' and dated December 10, 1868. The writer concludes that explosive bullets only cause useless mutilation, though for certain military purposes they might occasionally be employed with considerable advantage.

Wounds by small shot, note 33, *p.* 191.

I made a series of experiments with a breech-loading fowling-piece, using one of Eley's cartridges with No. 16 shot, about 250 in a charge, and, comparing them with the well-known experiments recorded by Dr. Lachèse, found the range at which the effects described by him were produced in all instances considerably extended. Thus Dr. Lachèse records that at a distance of 3 feet there was no longer any central opening from the shot; while in my trial of 15 feet there was still a central hole $1\frac{1}{4}'' \times \frac{3}{4}''$ in size, with scalloped edges and an irregular outline. About 100 shot had passed through this opening. Outside the central hole there were about 140 shot openings; some having passed singly, in other instances two side by side, in others three or more together, in others the shot combining to form an irregular rent, and all these being within a circle of about 7 inches in diameter. At 50 yards about 150 shot out of the 250 pierced a wooden target 8 feet high by 6 feet wide, generally penetrating the wood to their own depth. They were very widely scattered over the target, from top to bottom. The experiments of Dr. Lachèse showed great scattering of the shot at very short distances compared with the distances just mentioned.—See *Obss. et Expériences sur les Plaies produites par des Coups de Fusil Chargés à Poudre ou à Plomb, &c.*, par le Dr. Lachèse Fils: *Annales d'Hygiène Publique*, tome xv., 1836, p. 359.

SECTION IV

PRIMARY SYMPTOMS AND COMPLICATIONS OF GUNSHOT INJURIES

Pain of gunshot wounds of bones, note 1, *p.* 199.

Dr. Chenu mentions the case of an artilleryman in the Italian campaign of 1859 who had the neck of his left thigh-bone fractured by a bullet while he was loading his gun. The man, who had his leg advanced at the time, went on with what he was about, unconscious of what had happened, though conscious of a severe general shock; but on presently making an effort to draw himself upright, he tottered, and only avoided falling by supporting himself against a tree (*Campagne d'Italie,* tome ii. p. 290). He has also related the case of a mounted officer who had the neck of the thigh-bone broken by a bullet in the Franco-German war. Although sensible of a dull blow, he had no conception of the severe injury that had happened to him until he saw his limb drop from the stirrup, and found himself unable to replace it there (*Guerre de* 1870–71, tome i., intro. p. 31).

Sir C. Napier's shell wound, note 2, *p.* 201.

'Life of Sir Charles Napier,' vol. ii. p. 193. Diary.

Signs of pain exhibited by patients, note 3, *p.* 201.

When acting as Mr. Bransby Cooper's dresser at Guy's Hospital, I assisted at the case of a man who, while the knife was in the act of amputating his arm, laughed at the pale faces and general aspects of some of the students on the benches of the theatre above, who were probably seeing such an operation for the first time. This was, of course, before the days of anæsthetics. On the other hand, I knew an officer of standing in the army, a captain, who received a bullet wound of only a finger at the battle of the Alma, and who went about uttering such exclamations concerning the pain caused by it, and continued evincing such excitement, losing all rational control over himself, that his condition resembled that of a patient suffering from delirium.

Pain along bullet tracks, note 4, *p.* 203.

Extract from 'Life in India and Scenes in the Mutiny,' a lecture delivered in Halifax in 1860, by H. Chalmers-Miles, Assist.-Surgeon R.A., Halifax, N.S., 1860, p. 15.

Special sensory effects, note 5, *p.* 204.

'Injuries of Nerves, &c.,' by S. Weir-Mitchell, M.D., Phil., 1872, p. 146.

Hæmorrhage after gunshot wounds, note 6, *p.* 212.

It appears that death from hæmorrhage may sometimes be prevented without any material contraction of the arterial tube, and by quite a different process from that described in the text. Dr. Chenu has reported

a case which came under his notice in the Franco-German war, in which an operator, either ignorantly or recklessly, had amputated the thigh near the knee-joint, not only without making any flaps, but also without placing any ligature on the vessels. The amputation was done at eleven A.M., and the patient was not seen by a competent surgeon until after six P.M. There had been no hæmorrhage. The state of the popliteal artery at this time is thus described: 'The aperture of the vessel was scarcely at all contracted, but was almost entirely closed by the folding and knitting together of the internal coats, which appeared to be turned on themselves, with a direction inwards.' Dr. Chenu likens the state of the internal coats of the artery to the turning up and shrivelling which parchment exposed to the heat of fire exhibits; and he attributes the absence of hæmorrhage to this process, together with the hæmostatic effects of the shock of the original injury (smashing and almost entire removal of the limb below the knee by a fragment of shell), and of the clot which had formed on the face of the stump after the amputation.—Chenu, *Guerre de* 1870–71, tome i. p. 297.

Escape from primary hæmorrhage, note 7, *p.* 214.

Guthrie on 'Wounds and Injuries of the Arteries,' 1846, p. 22.

Arteries pushed aside by shell fragments, note 8, *p.* 216.

'Medical and Surgical History of the British Army in the Crimea,' vol. ii. p. 340.

Fatal hæmorrhage checked by a lodged bullet, note 9, *p.* 217.

Hunterian Museum, Prep. No. 1565.

Lodgment of conoidal bullets, note 10, *p.* 221.

Kriegschirurgische Erfahrungen gesammelt in Carlsruhe, 1870–71, von Dr. A. Socin, &c., Leipzig, 1872, p. 15.

Lodgment of fragments of uniform, note 11, *p.* 222.

The instances of such articles being lodged in gunshot wounds are very numerous. The fatal bullet which killed Lord Nelson entered his left shoulder, and carried a portion of his epaulette in with it. The epaulette with the hole in it is, or used to be, at Greenwich Hospital.

Lodgment of foreign bodies, note 12, *p.* 224.

Catalogue of the Surgical Section of the U. S. Army Med. Museum, xxvii. BB. No. 3236, d. 213.

Coins as secondary projectiles, note 13, *p.* 224.

Relation Chir. des Évènements de Lyon, 1835.

Foreign bodies from articles in pockets, note 14, *p.* 225.

Chenu, *Guerre de* 1870–71, Paris, 1874, tome i. p. 286.

Bullet and metal button lodged, note 15, *p.* 225.

Kriegschirurgische Erfahrungen gesammelt in Carlsruhe, 1870–71, von Dr. A. Socin, &c., Leipzig, 1872, p. 21.

Pistol holsters struck by bullets, note 16, *p.* 225.

The case mentioned in the text is quoted from Marjolin, *Clinique Chirurgicale,* p. 363. Holsters of mounted officers are frequently struck by bullets, owing to their position at the fore part of the saddle in front of the officers' thighs. In the early part of the battle of the Alma, as the Light Division was advancing in columns of battalions, I was riding in rear of my regiment when a bullet whizzed past my left cheek, and I heard it strike, as I thought, Colonel Shirley (afterwards Sir Horatio Shirley), who was immediately behind me at the head of the Connaught Rangers. I at once turned round, and Colonel Shirley, smiling, pointed to one of his pistol holsters which the bullet had penetrated. It was subsequently found that the bullet had been prevented from passing through the holster by a small Bible which the Colonel was carrying in it. Had it gone through, it must have wounded the Colonel in the thigh. The Bible, with the bullet lodged in the middle of it, is still preserved by the family.

Lodgment of bone fragments from other men, note 17, *p.* 226.

Hennen's 'Military Surgery,' 3rd edition, 1829, pp. 86 and 87.

Lodged coins from a comrade's pocket, note 18, *p.* 228.

Hennen, supra cit., p. 85.

Lodgment of shell fragments, note 19, *p.* 229.

Histoire Méd. du Blocus de Metz, par E. Grellois, ex-Médecin-en-chef d'Armée, Metz, 1872, p. 63.

Concealment of foreign bodies, note 20, *p.* 230.

For the history of this case see 'Cases and Communications illustrative of Subjects in Military and Naval Surgery,' by Sir G. Ballingall, *Edin. Med. and Surg. Journal,* vol. lvii. p. 116. Figures of the breech of the musket of full size, of the manner in which the foreign body protruded through the palate, and of a vertical section of the head showing the position in which it was lodged, accompany the history. An earlier history of the case, with some particulars not mentioned by Sir G. Ballingall, together with an additional drawing and an account of the post-mortem examination, are given in the *India Journal of Med. and Phys. Science,* vol. ii., N.S., Calcutta, 1837, p. 765. The history of the case is also repeated in Emerson Tennent's 'Ceylon,' vol. ii. p. 333.

Lodgment of the breech of a fowling-piece in the face for twenty-four years, note 21, *p.* 231.

For the particulars of this case I am indebted to Mr. F. F. Giraud of Faversham, who attended the patient, and to Mr. C. L. Alwork of Maidstone, who gave me the breech-piece concerned in it. The man, a farm-

labourer, by name Rickwood, was wounded on June 6, 1833, and remained at work from the time the wound healed. For some days previously to the escape of the breech-piece he had experienced sensations as if a piece of bone were coming away ; but as soon as the escape occurred he felt well, and went to his work as usual. About three years subsequently he was suddenly seized with a rigor, which was shortly followed by coma, and in this state he continued till his death, which occurred on June 2, 1860, the second day from the seizure. A post-mortem examination was made by Mr. W. N. Spong of Faversham, but the account of it furnished to me was very meagre. There was loss of substance in the portion of the brain that rests upon the cribriform plate of the ethmoid bone, and this accounted for the fact that he had lost all sense of smell from the time of the accident. The cause of the comatose symptoms does not appear to have been discovered. Some bone near the seat of injury was in a diseased condition. Three pieces of bone were removed at the time of the accident, but Mr. Alwork informed me there was no exfoliation subsequently, though there was at times discharge of fetid pus from the nostrils. The man constantly complained of headache, and frequently exhibited irritability of temper. The case is probably unique as regards the lodgment of such a heavy and irregularly shaped foreign body for so long a time in the face without detection. Excepting that no abscess appears to have been found post-mortem in Rickwood's case, the condition of the injured parts probably resembled that found in Lieut. Fretz's case. In the latter 'a small abscess was discovered in the anterior lobe of the right hemisphere of the brain. The bottom of the cyst rested on the frontal orbitar plate, and was connected with a dense membrane, which supplied the place of a triangular deficiency in the cribriform plate of the ethmoid bone. The crista galli remained, but was displaced and loosened. The cavity containing the iron appeared to be formed by the ethmoid and sphenoid cells, their internal bony structure having been absorbed. The position of the iron was nearly perpendicular, parts of it projecting into the mouth. It was easily removed. The opening through the palate admitted the forefinger up to the second joint. The back and lower part of the septum narium were destroyed, and there was an opening in the upper part through which the screw passed.' (Op. supra cit., p. 765). From some original documents concerning Fretz's case in my possession it appears that his mental faculties remained unimpaired from the date of his wound to the time of his death. Rickwood's condition was similar in this respect.

Lodgment of pieces of iron in the face, note 22, *p.* 231.

The history of Dr. Keith's case will be found in the *Medical Times and Gazette* of October 23, 1858. A side and front sketch of the breech, which was 2½ inches long, accompanies the history. Dr. Fraser's case is published in the *Edin. Medical Journal* for July 1856, p. 247.

Lodgment of bullet in the ethmoid bone, note 23, *p.* 231.

This and the fatal wounds alluded to in the text were instances of the accidental injuries which occasionally happen—perhaps more frequently than supposed—on all occasions when troops are closely engaged in the field. They were inadvertently inflicted by one of our allies, a French soldier, who was only a short distance off from the two men of the 42nd Regiment who were shot. Surgeon Mackinnon, 42nd Regiment, since Sir Wm. Mackinnon, K.C.B., attended the soldier when wounded in 1855 ; the post-mortem inspection in 1859 was made by Surgeon Furlong, 42nd Regiment.

Bullet impacted in the tibia, note 24, *p.* 232.

'Amer. Med. Times,' 1863, vol. ii. p. 288.

Neglect of proper exploration of gunshot wounds, note 25, *p.* 233.

Laurent, the author of the Life of Baron Percy, has related this case, and it is one which conveys a lesson that is worth repeating. An aide-de-camp was wounded in the mouth by a piece of shell. The front teeth were broken away from the lower jaw. Much swelling quickly followed the injury. A surgeon of high grade, or, as Percy designates him, a medical officer, who was unfortunately superior *only* in grade, saw the patient, and, without troubling himself to make a proper exploration, flippantly asserted that the wound was nothing, and would only cost him a fresh set of teeth. As the effects of the wound became more grave, another surgeon was called to see the wounded officer. Putting a finger into the mouth, and making the requisite examination, he at once felt a fragment of iron lodged there, and removed it. It weighed several ounces. But the discovery was too late—the patient died, suffocated from extension of swelling to the neck. The carelessness of the surgeon who had first seen the patient, and the inconsiderate manner in which he had spoken of the wound, became known to the soldiers of the army, and they conferred on him an ironical nickname, 'Père la Grenade,' which caused the occurrence to be associated with him ever afterwards.

Lodgment of a second bullet undetected, note 26, *p.* 234.

Army Med. Mus., Netley, Spec. No. 2939. Ununited fracture of femur, the result of two bullets having entered through one and the same opening. One extracted, the other remaining lodged at seat of fracture.

Lodgment of heavy projectiles, note 27, *p.* 234.

Chenu, *Campagne d'Italie*, vol. ii. p. 299.

Prolonged retention of lodged missiles, note 28, *p.* 235.

Chenu, op. cit., p. 300.

Absence of burns in melinite explosions, note 29, *p.* 173.

See *Note sur les Effets de la Melinite* (*Accident de Belfort*), par Tachard, Méd.-Major de 1re. Cl., in Archives de Méd. et de Pharm. Mils., tome 10ème, p. 161, Paris, Rozier, 1887. Although the shell alluded to in the text was not burst with the force it would have possessed had it been fired from a gun and exploded by a detonating fuze, still seventeen gunners were wounded by it: five being killed on the instant, six dying in hospital, and only six surviving after treatment. The several injuries inflicted are fully described by Dr. Tachard.

Multiple wounds of internal organs, note 30, *p.* 241.

This case is described in my article on gunshot wounds in the first edition of Holmes' 'System of Surgery,' which was reprinted in the United States during the civil war, and was issued for use in the army by the U. S.

Hospital Department, without the slightest regard or remuneration to the publisher, Mr. Parker, to whom it belonged. Dr. Otis, in his 'History of the War of the Rebellion,' Surg. vol., part ii., p. 70, refers to the case, and remarks it was 'observed by Alexander in the Crimea.' But it was not observed by him, as he was not one of those who were present at the post-mortem examination. Dr. Alexander was the principal medical officer of the Light Division, in which the 19th Regiment was; and I, as surgeon of the regiment, reported the case to him in due course, and he in turn mentioned it in a letter to Mr. Guthrie.

I have presented a copy of the American reprint of my article on gunshot wounds, with the United States Hospital Department stamp upon it, to the Medical Staff Library at Netley. The little book in question was not only distributed from the Surgeon-General's office at Washington, but was one of the articles named in the 'Standard Supply Tables' of the U. S. military hospitals. I should not have referred to this fact, were it not that a list, purporting to be a complete one, of the works on gunshot wounds available for reference in the United States at the time the war broke out, has been given in the first part of the 'Surgical History of the War of the Rebellion,' and mention of this particular one, although it was generally circulated in the U. S. hospitals, is altogether omitted.

Multiple wounds from cross-fire, note 31, *p.* 242.

Surgical History of the U. S. War, op. cit., part iii. ch. xii. p. 168.

Repeated wounds while lying on the field, note 32, *p.* 242.

Surgical History of the U. S. War, op. cit., part iii. p. 869.

Multiple wounds, note 33, *p.* 243.

Army Medical Reports, vol. vii. p. 473.

Men stabbed after having been shot, note 34, *p.* 244.

'Medical and Surgical History of the Crimean War,' vol. ii. p. 262. The animus with which these lance and bayonet stabs are inflicted on men already suffering from gunshot wounds is well shown in an incident of the touching narrative by Col. Ponsonby of his multiple wounds and injuries and multiplied sufferings as he lay on the field of Waterloo: 'Recovering, I raised myself a little to look round, being at that time, I believe, in a condition to get up and run away, when a lancer, passing by, cried out, "Tu n'es pas mort, coquin!" and struck his lance through my back. My head dropped, the blood gushed into my mouth, a difficulty of breathing came on, and I thought all was over' (quoted by Chaplain-General G. R. Gleig in his 'Story of the Battle of Waterloo,' London, 1847, p. 200). Rage, unreflecting excitement, forgetfulness that the actor's own condition may shortly be the same as that of his fallen foe, the dreadful callousness to suffering and disregard of life that habits of fighting engender in so many men, and a feeling, perhaps, that the greater number of enemies that are killed the greater one's own security, all conduce to occasional heartless infliction of such aggravated suffering on fields of battle.

Multiple wounds from shell fragments, note 35, *p.* 244.

'Surgical History of Crimean War,' vol. ii. p. 330. The patient referred

to in the text was discharged from the service at Chatham on December 20, 1855, all his wounds being then healed.

Multiple amputations from gunshot wounds, note 36, *p.* 246.

'What we Observed at the Seat of War in 1870,' by C. Orton and W. D. Spanton, London, 1871, p. 11.

SECTION V

AIDS TO DIAGNOSIS OF GUNSHOT INJURIES

Evidence furnished by clothes, note 1, *p.* 250.

'A Treatise on Gunshot Wounds, &c.,' by G. T. Guthrie, London, 1820, p. 20; Hennen, 'Prin. of Mil. Surgery,' London, 1829, p. 36; Jobert De Lamballe, *Plaies d'Armes à Feu*, Paris, 1833, p. 32.

Clothes proving wound to have been self-inflicted, note 2, *p.* 251.

Marshall, 'On the Enlisting, Discharging, and Pensioning of Soldiers,' Edinburgh, 1839, p. 141.

Evidence furnished by a single hair, note 3, *p.* 257.

For a complete history of this case, see *Amer. Journal of the Med. Sciences*, vol. cxxiv., October 1871, p. 385.

Evidence furnished by projectiles, note 4, *p.* 259.

'Cat. of Museum of Mil. Surgery, Netley,' Appendix, Spec. No. 609C.

Vertebral injury demonstrated by a bullet, note 5, *p.* 261.

For a full history of this case, see the *Lancet*, vol. i. for 1855, p. 607; and 'Guy's Hosp. Reports,' 3rd Series, vol. v., 1859, p. 173.

SECTION VI

SECONDARY COMPLICATIONS OF GUNSHOT INJURIES

Gangrene from cold during the Crimean war, note 1, *p.* 274.

For a very complete and excellent account of the gangrene of combined cold and bodily debility as they occurred among the British troops in the Crimea, see the summary of Dr. Hanbury in the 2nd volume of the Official Medical and Surgical History of the War, sect. viii. p. 187 to p. 193; see also Return A. in the same volume, p. 251, showing the monthly admissions into hospital, and deaths, from disease and injury in the army of the East.

Gangrene after shot wounds in the U. S. civil war, note 2, *p.* 274.

See the Surg. History of the War, part iii. pp. 825.

Suddenly developed general gangrene, note 3, *p.* 276.

'Report on the Pathology of the Diseases of the Army in the East,' London, 1856, p. 105. Dr. Lyons was sent by Lord Panmure, in April 1855, to conduct pathological researches in the hospitals of the army in the East. Dr. Lyons' researches were chiefly pursued in the Crimea, while Dr. Aitken, who was with him as first assistant, conducted the investigations at Scutari.

Gangrene in Crimean hospitals, note 4, *p.* 276.

See Report by Dr. Lyons, above named, p. 275.

Rapidly destructive gangrene in war hospitals, note 5, *p.* 278.

Prof. Delorme of Paris, who describes this form of gangrene under the name of 'Gangrène gazeuse foudroyante,' states that it has claimed many victims among the wounded in field and fixed army hospitals since the Crimean war. He refers to the descriptions by Dr. Salleron of it as it appeared epidemically among the wounded in the crowded hospitals on the Bosphorus, by Dr. Chenu as witnessed in the Italian campaign of 1859, and Franco-German war of 1870–71, and by other observers who saw it during the reign of the Commune at Paris.—*Traité de Chirurgie de Guerre*, par E. Delorme, Paris, 1888, tome i. p. 579.

Varieties of secondary hæmorrhage, note 6, *p.* 282.

'Reports of Observations in the Brit. Mil. Hospitals in Belgium,' &c., by J. Thomson, &c., Edinburgh, 1816, p. 47.

Periods of secondary hæmorrhage, note 7, *p.* 282.

Guthrie, 'Commentaries on the Surgery of the War in Portugal,' &c., London, 1853, p. 203.

Hospital gangrene in the Peninsular war, note 8, *p.* 287.

'Commentaries on the Surgery of the War in Portugal,' &c., by G. T. Guthrie, F.R.S., London, 1853, p. 169.

Hospital gangrene in the Sikh war, note 9, *p.* 287.

Guthrie, op. cit., p. 165.

Hospital gangrene in French army hospitals, note 10, *p.* 289.

Traité de Chirurgie d'Armée, par L. Legouest, Paris, 1872, p. 650.

Hospital gangrene in India, note 11, *p.* 290.

'Madras Quarterly Journal of Medical Science,' July 1, 1860, p. 22, &c.

Hennen's Obs. on hospital gangrene, note 12, *p.* 290.

'Principles of Military Surgery,' by John Hennen, M.D., London, 1829, pp. 217–20.

Blackadder's views on hospital gangrene, note 13, *p.* 291.

'Observations on Phagedæna Gangrænosa,' by H. Home Blackadder, Edinburgh, 1818, p. 39.

Guthrie on hospital gangrene, note 14, *p.* 293.

Guthrie, op. cit., p. 158.

Infectious nature of hospital gangrene, note 15, *p.* 294.

See Blackadder, op. cit., p. 43 ; and Legouest, op. cit., p. 651.

Hospital gangrene communicated by sponges, note 16, *p.* 295.

'A System of Surgery,' &c., edited by Holmes, London, 1870, vol. i. p. 164.

Hospital gangrene communicated by attendants, note 17, *p.* 295.

Mr. Barker's paper is published in the *Medical Press and Circular* of March 19, 1873, p. 243.

Hospital gangrene communicated by foul air, note 18, *p.* 295.

Hennen, op. cit., p. 235.

Hospital gangrene not produced without direct contact, note 19, *p.* 296.

Blackadder, op. cit., pp. 46, 47.

Hospital gangrene in United States civil war, note 20, *p.* 296.

Surgical History of the War, op. cit., part iii. p. 833, &c.

Conditions favouring the spread of hospital gangrene, note 21, *p.* 297.

Consult Hennen, op. cit., p. 241, and other observers on this subject.

Influence of mental depression on spread of hospital gangrene, note 22, *p.* 298.

'Surgical History of United States War,' op. cit., part iii. p. 830.

Hunter on pyæmia, note 23, *p.* 299.

'Very strange instances of translation are given to us; it has been supposed that pus already formed has been translated to another part of the body, deposited there in the form of an abscess, and then discharged. This is absolutely impossible.'—The Works of John Hunter, edited by Palmer, London, 1837, vol. iii. p. 395.

Tetanus in the West Indies, note 24, *p.* 310.

'Obs. on the Dis. of Seamen,' by Gilbert Blane, M.D., London, 1789, p. 519. From the account given, it appears 810 men were wounded in the actions of April 1782, of whom 266 were killed outright, 67 died of their wounds on board, and 21 in hospital on shore.

Tetanus during the Peninsular war, note 25, *p.* 310.

'Medico-Chirurgical Trans.,' vol. vi. p. 449.

Relative number of cases of tetanus in former wars, note 26, *p.* 310.

Ballingall's 'Outlines of Military Surgery,' Edinburgh, 1838, p. 257.

Absence of tetanus at Paris in 1848, *note* 27, *p.* 310.

Communication de M. Roux à l'Académie Nat. de Méd.; Séance de 1*er Août* 1848.

Tetanus in Crimean war among British wounded, note 28, *p.* 310.

Official Surgical History, p. 284. Two other cases occurred in the field —one after frost-bite, the other probably idiopathic. There were five cases at Scutari during the winter of 1854–55—three among wounded from the Crimea, one in a patient suffering from dysentery and frost-bite, and one idiopathic. A sixth case occurred in England; it followed amputation for diseased bone consequent on frost-bite in a Crimean invalid. There were thus twenty-nine cases of tetanus from all causes among the officers and men who were engaged in the military operations against Russia in 1854–56.

Tetanus in Crimean war among French wounded, note 29, *p.* 310.

Relation Méd. Chir. de la Campagne d'Orient, par le Dr. G. Scrive, Paris, 1857, pp. 349, 448, and 460. Dr. Chenu has not given a table of cases of tetanus in his 'History of the Crimean War.'

Tetanus in Crimean war among Russian wounded, note 30, *p.* 311.

Kriegschirurgie, N. Pirogoff, p. 928.

Tetanus in the Italian war of 1859, *note* 31, *p.* 311.

Campagne d'Italie, par le Dr. Chenu, Paris, 1869, tome ii. p. 396. Numerous reports on tetanus by French surgeons, as observed in the Italian war, with illustrative cases of much interest, are quoted by Dr. Chenu. See also Dr. Demme, *Algemeine Chir. der Kriegswunden in den Norditalienischen Hospitälern von* 1859. Würzburg, 1861, pp. 146–56, and Appendix, p. 283.

Tetanus during United States civil war, note 32, *p.* 311.

'Med. and Surg. Hist. of the War of the Rebellion;' Surg. Hist., part iii. vol. ii. p. 818.

Tetanus in war of Indian Mutiny, note 33, *p.* 312.

'Notes on the Surgery of the Indian Campaign of 1857–58,' by J. Brown, M.D., Bengal Med. Service, in the *Indian Lancet*, 15th December, 1860, p. 376.

Tetanus and lodgment of cloth, note 34, *p.* 314.

Recueil de Mém. de Méd. et Chir. Mil., tome v., 1861, p. 392.

Nerve lesions and tetanus, note 35, *p.* 315.

'Med. Chir. Trans.,' vol. iv. p. 48. 'Case of wound of the radial nerve.'

Lesions of cutaneous nerves, note 36, *p.* 315.

'Injuries of Nerves,' by S. Weir-Mitchell, M.D., Phil., 1872, p. 147.

Atmospheric changes and tetanus, note 37, *p.* 316.

Mém. de Chir. Mil., &c., par D. J. Larrey, Paris, 1812, tome iii. p. 286 and p. 292.

Effects of damp in producing tetanus, note 38, *p.* 316.

Circ. No. vi., W. D., Surgeon-General's Office, Washington, 1st Nov. 1865.

Tetanus at Strasburg in 1870, *note* 39, *p.* 316.

Guerre de 1870–71, Chenu, tome i. pp. 476–78.

Changes of temperature with damp, note 40, *p.* 316.

Hammond, 'Diseases of the Nervous System,' New York, 1871, p. 534.

The bacillus tetani, note 41, *p.* 318.

A summary of the investigations regarding the so-called *bacillus tetani* may be seen in Dr. C. Flügge's work on 'Micro-organisms, with special reference to the Etiology of the Infective Diseases,' translated by Dr. W. W. Cheyne, and published by the New Sydenham Society. (See vol. 132, London, 1890, pp. 240–43.)

The following are the chief facts contained in it. Nicolaier, of the Göttingen Hygienic Laboratory, found that, when certain kinds of garden earth was introduced under the skin of mice and rabbits, the usual symptoms of tetanus were caused, and death followed, in the mice, on an average at the end of three days, and in the rabbits, from the fifth to the seventh day, after inoculation. In the pus at the seat of inoculation fine bacilli were constantly present. These bacilli could not be directly demonstrated in the garden earth itself. When specimens of the earth were heated to (190° C., 374° F.) they produced no effect though introduced in larger quantity. The inference was that the micro-organisms were destroyed by the heat to which the earth had been subjected. The tetanus could be transmitted from animal to animal by inoculation with small quantities of pus from the diseased animal. Two Italian observers removed some tissue from the seat of infection of a patient who had died of tetanus, and injected

some emulsion made with it into the spinal muscles, or spinal canals, of some rabbits, and eleven out of twelve became tetanic. 'The disease corresponded absolutely in its symptoms and course to that which Nicolaier had produced, and could be transmitted from animal to animal by inoculation of portions of the sciatic nerve.' These are the main facts on which the supposition rests that certain bacilli are the specific exciting agents of tetanus.

Period of occurrence of tetanus, note 42, *p.* 320.

'Holmes's System of Surgery,' 2nd edition, vol. i. p. 319.

Tetanus lessened by better sanitation, note 43, *p.* 321.

'Med. Chir. Transactions,' vol. vii. p. 465.

Acute and chronic tetanus, note 44, *p.* 322.

Larrey, op. cit., tome i. p. 235, et tome iii. p. 286, and 'Hennen's Mil. Surgery,' London, 1829, p. 249.

Erysipelas rare among coloured troops, note 45, *p.* 323.

Surgical Hist. of U. S. War, part iii. p. 857.

Traumatic delirium, note 46, *p.* 333.

Aperçu Historique, Statistique, et Clinique sur le Service des Ambulances, &c., pendant la Guerre de 1870–71, par le Dr. J. C. Chenu, Paris, 1874, tome i. p. 475.

Plague of flies in the Crimean hospitals, note 47, *p.* 336.

'Med. and Surg. Hist. of War against Russia,' vol. ii. p. 274.

Larvæ in wounds in U. S. civil war, note 48, *p.* 336.

Surg. Hist. of the War, op. cit., part iii. p. 867.

Flies in Indian hospitals in the Mutiny war, note 49, *p.* 337.

See 'Indian Annals of Med. Science,' No. x., Calcutta, July 1858, p. 401.

Larrey on larvæ in wounds, note 50, *p.* 337.

Mém. de Chir. Mil., &c., Paris, 1812, tome i. p. 311.

SECTION VII

ULTIMATE SEQUENCES OF GUNSHOT WOUNDS

Remote effects of lodged substances, note 1, *p.* 340.

Hunter's Works, edition 1794; 'The ulcerative inflammation,' p. 450.

Lodgment of organic substances, note 2, *p.* 343.

Handbuch der Kriegs-Chir., &c., von J. Neudörfer, Zweite Hälfte, Leipzig, 1869, pp. 590, 591.

Coils of linen lodged in gunshot wounds, note 3, *p.* 343.

In a case of lung wound related in the *Journal of the Medical Sciences* for 1845, by Dr. Houston, a sinus existed for twenty-five years, and, after death, a linen fragment, 'coiled up in the shape of a silkworm,' two and a half inches long by two wide, was found in a cavity connected with it. A similar coil of linen had prevented the final healing of a wound of the lung in a military invalid who died at Chatham a year after he received his wound in India. A full report of this case was published in my article on gunshot wounds in Holmes's 'System of Surgery.'

Remote effects of gunshot wounds, note 4, *p.* 358.

'System of Surgery,' edited by Holmes, &c., London, 1870, vol. ii. p. 226.

Perforations of the head by bullets, note 5, *p.* 362.

Particulars of fourteen instances in which soldiers survived after complete perforations of the head by musket bullets are recorded in the 'Surgical History of the War of the Rebellion,' vol. i. pp. 206–209. The pension-examining surgeons regarded the resulting disabilities as total and permanent in all these cases. Out of 4350 gunshot injuries of the cranium tabulated, 73 appear as 'perforating fractures.'

Disabling effects of gunshot lung wounds, note 6, *p.* 369.

Reports in detail of the cases alluded to in the text are printed in Army Medical Reports, vol. xxiii., London, 1883, pp. 297–307.

Fistulous openings persisting after chest wounds, note 7, *p.* 370.

Op. cit., part i., Surg. vol., Washington, 1875; Wounds of Chest, sect. iv. chap. v. p. 629.

Survivors after gunshot wounds of the liver, note 8, *p.* 373.

United States War, op. cit., Surg. vol., part ii. p. 46, &c.

Disability after closure of gunshot stercoral fistula, note 9, *p.* 374.

The case of this soldier was fully described by the late Professor De Chaumont in the *Edinburgh Medical Journal* of 1858.

Disabilities after healed stercoral fistula, note 10, *p.* 374.

See Army Medical Department Report for 1883, p. 282 of Appendix, for full details of the case mentioned in the text.

Ulterior effects of bullet lodged in abdomen, note 11, *p.* 375.

An account of this case is published by Dr. W. J. Rundle, Major B.'s medical attendant, in the *Medical Times and Gazette*, 1866, vol. i. p. 306. A sketch of the bullet and parts implicated in the obstruction, by Dr. J. Ward Cousins, accompanies it.

Resection after gunshot wound of shoulder-joint, note 12, *p.* 384.

Ligamentous union with recovery of great power. See case of Sergeant M., illustrated in vol. v., Army Medical Reports, London, 1865, Appendix, p. 564.

Resection after gunshot wound of elbow-joint, note 13, *p.* 384.

Extensive removal of bone, with recovery of great power. Case of General F. Lance. Six fragments of the bones excised are preserved in glass case, No. 3878, Pathological Museum, Netley.

SECTION VIII

TREATMENT OF GUNSHOT INJURIES

Clearing fields of action, note 1, *p.* 398.

There is reason to fear that some men in a comatose condition from injuries to the head, others suffering from collapse after hæmorrhage, or from profound shock after severe wounds, have been occasionally buried after battles on the supposition that they were dead. It has been sufficiently established that any one of the usual signs of death, excepting decomposition, may be present and life yet be not extinct. It has also been shown by Professor Rosenthal of Vienna and others that the only test, short of decomposition, which shows death to have taken place with absolute certainty is the absence of electro-muscular contractility on the application of a faradic current. The means of applying this test may exist in general hospitals, but cannot be expected to be found on fields of battle. In its absence, the fact of the complete cessation of the heart's action, and the presence of some of the other usual signs of death, can only be properly determined by a medical officer, or at least can be more surely established by him than by a non-professional observer.

Field tourniquets, note 2, *p.* 401.

Dr. D. Foulis' improved elastic tourniquet. This contrivance acts on the same principle as the temporary expedients for checking bleeding explained in the text, but would be even more dangerous if put to general use in the field. It was introduced early in the year 1875. It consists of a solid vulcanised india-rubber cord. The two ends, after the cord has been put on the stretch, can be quickly and firmly secured by a very ingenious catch which is attached to it. They fix themselves in the catch by their own elasticity. This instrument answers admirably as an elastic band for

temporarily keeping back the afflux of blood to a limb which has been previously prepared for the performance of a bloodless operation on a patient in a state of anæsthesia, for the whole limb is firmly constricted by it, and the circulation is completely stopped. But the very qualities which make it answer this purpose obviously render it dangerous as a field tourniquet. Moreover, the pain caused by it in patients with their senses unblunted quickly becomes intolerable. The pressure is the same at every point of the circumference of the limb, and is necessarily very great, from the manner in which the ends of the india-rubber are secured in the catch; while it does not admit even of the amount of adjustment which can be obtained, by a little management, in Esmarch's elastic bandage or the common pad and buckle tourniquet.

Risks attending use of field tourniquets, note 3, *p.* 402.

Dr. Lee, in his pamphlet on the uses and applications of Lambert's elastic tourniquet, states he was informed 'by a brigade-surgeon, who was at Bull's Run, where more than two thousand were wounded, that the use of the field tourniquet was so frequently followed by mortification and the loss of the limb, that he had come to the conclusion it was far safer to leave the wounded to nature, without any attempts to arrest the flow of blood, than to depend upon the common army tourniquet.' He also quotes the following passage to the same purport from Dr. M'Clellan's 'Princ. and Prac. of Surgery,' Phil., 1848: 'The usual practice on the field is to check hæmorrhage immediately by the application of a tourniquet, or some extemporaneous substitute, which answers a temporary purpose at the expense of a most injurious congestion of the wound and all the parts below. In hot weather especially, vascular engorgement, tumultuous excitement, and mortification are ensured by such a rude and mechanical instrument. The surgeon would, in general, do vastly better by leaving the wound in the hands of nature under such circumstances.'

Winged tourniquets, note 4, *p.* 402.

See a pamphlet entitled, 'A Description of the Newly-invented Elastic Tourniquet, for the Use of Armies, &c.,' by C. A. Lee, M.D., New York, 1862.

Dr. Mott's winged tourniquet, note 5, *p.* 404.

A drawing of this instrument may be seen in the essay on 'Hæmorrhage,' at p. 403 of the vol. of 'Mil. Med. and Surg. Essays, prepared for the U. S. San. Commission,' edited by W. A. Hammond, &c., Phil., 1864; also in the 'Surgeon's Pocket Book,' by Porter, London, 1875, p. 204.

Surgeon-Major Moffitt's winged screw tourniquet, note 6, *p.* 405.

See a description by Surgeon-Major Moffitt of his tourniquet in the *Brit. Med. Journal* for January 1874, p. 16. The Museum of Military Surgery at Netley contains specimens of the winged tourniquets referred to in the text, and various other kinds of field tourniquets.

Distribution of tourniquets, note 7, *p.* 406.

Dr. Mott advocated the general introduction of tourniquets among troops in his essay on 'Hæmorrhage,' not only on account of its advantage in stopping loss of blood, but also on account of the moral courage and

confidence which the possession of the instrument would give to soldiers. The arguments of this distinguished surgeon do not, however, appear to me to overrule the practical difficulties and inconveniences which would attend such a general distribution of tourniquets. Several surgeons of high position in the United States, when testifying to the merits of Lambert's tourniquet, express the view that every soldier should have one as a 'life preserver.'

Digital control of hæmorrhage, note 8, *p.* 407.

Demme, op. cit., p. 119. Among others, Dr. Demme particularises the case of a young Austrian soldier who was wounded at Melegnano in the left thigh, during the attack of the Zouaves. Feeling the warm blood flowing down his leg, he tore open his trouser, introduced his left thumb into the wound, and kept it in that position for four hours. At the ambulance the femoral artery was found to have been perforated one inch below the origin of the profunda branch, and a double ligature was then applied. The wounded man dwelt with justifiable pride on the coolness and presence of mind which he had displayed in carrying out this means of self-preservation for so long a time.

Exploration of gunshot wounds, note 9, *p.* 415.

The rule, to place the patient in the same position he was in when wounded, was followed before fire-arms were invented. It was the established practice in the extraction of arrows, darts, and other similar missiles, and was simply continued when shot from fire-arms had to be taken out of the body. Ambrose Paré, in the short account which he gives of his service at the siege of Perpignan in 1545, mentions a case in which he gained great credit by attention to this rule. M. de Brissac, grand master of the artillery, was wounded, on the occasion of a sortie from the town, by a bullet in the shoulder. Lying on a bed in his tent, he was examined by several of the most eminent surgeons with the army, and they, being unable to find any trace of the bullet, declared it had passed into his chest. Having known Paré before, M. de Brissac sent for him. Paré made him get up from his bed, and place himself in the position in which he was when he was hit. This at once gave Paré the cue. Following the direction of the wound with his hand as the patient stood in position, he presently came upon a little swelling beneath the scapula, determined this to be the site of lodgment, and from it shortly extracted the bullet.

Digital exploration of gunshot wounds, note 10, *p.* 421.

Some eminent surgeons have objected to exploring gunshot wounds by the finger for establishing an early diagnosis, but I do not think they do so on sufficient grounds. That the evil effects, described in the text, of abstaining from exploring wounds in the way mentioned are not imaginary, I will quote a portion of a letter written to me by a very experienced surgeon in 1865 during the last war in New Zealand: 'Some cases have shown how extremely necessary is a careful examination by the finger of all wounds on the field. I may especially mention the shoulder-joint cases. These were first seen by inexperienced assistant-surgeons, who neglected examining them with the finger, and consequently with the probe were not aware of the real nature of the injuries. The wounds were not diagnosed, as affecting the joints, at the very period above all others when it was easy to do so. Days passed on before it was possible to decide, from the great swelling, inflammation, and infiltration of the tissues, what was the real nature of the damage done. In some of the cases in which an examination was tried, it

had to be desisted from, owing to its causing extreme pain and suffering. After being from five to six days in hospital, the peculiar character and odour of the discharge gave indubitable indications of the exact nature of these wounds. The case of —— also well exemplifies what I have remarked He was wounded in the shoulder-joint; no digital examination was made; and, being under another surgeon, I did not examine the wound. I was repeatedly assured the joint was safe, although I never agreed to this, particularly on account of the nature of the discharge. After three weeks of intense suffering and serious constitutional disturbance, I urged the propriety of placing the patient under chloroform and thoroughly exploring the wound. This being done, not only was fracture found to be present, but the greater portion of the head of the humerus was dislocated back on the scapula. You may picture to yourself the effects of this on a patient of an irritable and highly strumous constitution; it nearly cost him his life. Had all these cases been at once recognised on the field, primary operations would certainly have been resorted to, with a most considerable reduction in the constitutional suffering and bad after-effects to the patients.

'In ——'s case, too, it was self-evident how very different would have been the final results in a man of his constitution, had a primary operation been practised; and the extreme severity of the injury would have settled the necessity of the procedure, had it been diagnosed at once, by examination with the finger, after the receipt of the wound.'

I have quoted this passage at length, as it so strongly illustrates the necessity for establishing a correct diagnosis of penetrating gunshot wounds at the earliest opportunity, by digital exploration. If further evidence be necessary for impressing the importance of this point of practice on the minds of young field surgeons, I may mention that on asking my able friend Dr. Frank, who was actively engaged in volunteer ambulance work throughout the late Franco-German war, what was the most important lesson this further experience in the field had taught him, his reply was, 'I have more than ever seen the ill results of neglecting the early exploration of wounds, and the good results to patients and surgeons when the diagnosis of them had been thoroughly established at the first examination.'

Extraction of foreign bodies, note 11, *p.* 431.

Histoire de l'État et du Progrès de la Chir. Mil. en France, &c., par M. Briot, Besançon, 1817, p. 97.

Dressings for gunshot wounds, note 12, *p.* 437.

Among the numerous specimens of materials for dressing wounds in military practice which the Museum of Military Surgery at Netley contains, are the following descriptions of oakum:—

No. 725. Surgeon's tow, carbolised. Fibres of variable thickness, uneven, and moderately rough. Readily separates into very short pieces. Very little odour of tar. Feels slightly greasy between the fingers.

No. 726. Sample of oakum used for dressing wounds at Paris during the siege of 1870–71. Fibres very coarse, rough, and of variable thickness. Tarry odour strong.

No. 727. Tenax. Specially prepared for surgical purposes. Fibres coarse, but not so much so as No. 726. Contains many short harsh pieces among it. Breaks up readily under pressure, and numerous dusty small portions drop from it.

No. 728. Calvert's carbolised tow. Fibres long, hair-like, even in thickness, soft to the touch, free from knots and hard lumps, and reddish-brown in colour. They present a silk-like glossy appearance. The tarry odour is

very strong. It feels greasy to the touch. This carbolised tow wants the springiness that characterises the oakum made from ropes.

Antiseptic applications, note 13, *p.* 439.

'On the Treatment of Gunshot Wounds by Chloride of Zinc,' by Wm. R. Smart, M.D., C.B., Ins. Gen. R.N., *Brit. Med. Journal*, October 22, 1870, p. 434. See also a paper in the *Lancet*, October 1870, p. 562, by Dr. Smart.

Chloride of zinc in gunshot wounds, note 14, *p.* 439.

'On the Treatment of Gunshot Wounds by Chloride of Zinc,' by Mr. C. de Morgan, F.R.S., &c., in the *Brit. Med. Journal*, October 15, 1870, p. 410. See also a communication 'On the Use of Chloride of Zinc,' in the *Brit. and For. Med. Chir. Review* for January 1866, p. 201.

Salicylic acid in gunshot wounds, note 15, *p.* 440.

Die antiseptische Wundbehandlung in der Kriegschirurgie von Dr. F. Esmarch, &c. Vortrag, gehalten in der ersten Sitzung des Congresses am 19 April, 1876. Trowitzsch und Sohn, Berlin.

Treatment by hermetically sealing, note 16, *p.* 447.

Dr. J. Julian Chisolm, Professor of Surgery in the Medical College of South Carolina, and author of a very handy and concise 'Manual of Military Surgery for the Use of Surgeons in the Confederate States Army.' This work, though comparatively of small size (3rd edition, small 8vo, 529 pp.), contained an epitome of information on military surgery, military hygiene, and twenty-six plates of the principal surgical operations, with a descriptive text.

Failure of process of hermetically sealing wounds, note 17, *p.* 449.

Surgical History of U. S. War, part i. p. 200, also pp. 417–514.

Treatment by pneumatic occlusion, note 18, *p.* 449.

An account of the treatment of wounds by 'Pneumatic Occlusion' was published by Dr. Jules Guérin, in the form of a pamphlet. See also a fresh note on the treatment of wounds by 'Pneumatic Occlusion,' read at the Paris Academy of Medicine, 9th August 1870, by Dr. Guérin. There had been previous discussion on the same subject at the Academy. Dr. Guérin treated cases of gunshot wounds by his method during the siege of Paris, and according to Dr. Guérin's statement, as reported by Surgeon-General C. Gordon, 'in nineteen cases of grave wounds of the limbs, some through the larger joints, there was only one death. The patients who were thus treated were said to have escaped pyæmia, although that disease was extensively prevalent in other rooms of the same building.'—Report on Military Hygiene and Surgery during the Siege of Paris, 1870–71, by C. A. Gordon, M.D., C.B., &c., p. 53.

Treatment by cotton-wool, note 19, *p.* 449.

'A New Method of Treating Wounds (Gruby's system),' &c., by C. F. Stuart Macdowell, Surgeon, Indian Army, &c., London, Churchill, 1871, p. 35.

Exploring instruments, note 20, *p.* 464.

Chemical reagents are not altogether abandoned for this purpose. M. Desneux, in 1872, suggested a plan for adoption which he had used in three cases with success. The end of a flexible rod is covered with a piece of lint steeped in dilute nitric acid, which is pressed for a few minutes against the supposed foreign body. On being withdrawn it is applied to a solution of iodide of potassium. If lead be present, the yellow colour of iodide of lead will appear.—*Bull. de l'Acad. de Méd. de Paris*, 16th July 1872.

Detection of lodged bullets by electric instruments, note 21, *p.* 467.

Gazette des Hôpitaux, 29th Nov. 1862, p. 553. A history of the use of electricity for the discovery of projectiles lodged in the body will be found in chap. iv. sect. 3, of the valuable work on 'Medical Electricity, &c.,' by Julius Althaus, M.D., 3rd edition, London, 1873.

Bullet lodged in General Garibaldi's wound, note 22, *p.* 467.

Storia della ferita del Generale Garibaldi, toccata il 29 *Agosto* 1862, *in Aspromonte*, compilata dal Dottor Giuseppe Basile, &c., &c., Palermo, 1863, p. 23.

Various substances lodged and electric exploration, note 23, *p.* 469.

The projectiles named in the text are preserved in the Museum of Military Surgery at Netley.

Endoscopic search for lodged substances, note 24, *p.* 470.

See the *Wiener Medizinische Wochenschrift* of 24th June 1870.

Bullet-extractors, note 25, *p.* 470.

The description of bullet-extractors given in the text agrees with the specimens of them which form part of the collection in the Museum of Military Surgery at Netley.

Delorme's bullet-extractor, note 26, *p.* 476.

Chirurgie de Guerre, par E. Delorme, tome ii., Paris, 1893, p. 1004.

Ruspini's bullet-extractor, note 27, *p.* 476.

See a description of 'A Newly-invented Instrument for the Extraction of Balls from Gunshot Wounds, &c.,' by J. B. Ruspini, London, 1813, in 'Medical Tracts,' vol. x.

Percy's tribulcon, note 28, *p.* 481.

Drawings of this instrument of full size, as well as a description of the manner of using it, may be seen in Percy's well-known work, *Manuel du Chirurgien d'Armée*, Paris, 1792.

Mouij's tire-balle, note 29, *p.* 481.

See a pamphlet entitled *Description d'un nouveau Modèle de Tire-balle dont on peut construire sept differents Instruments, &c.*, par C. de Mouij, Méd. Militaire de 2e classe de l'armée des Pays Bas, Maestricht, 1866. It includes fifteen drawings, showing the manner of adapting the instrument to the various uses for which it has been designed. A specimen of Dr. Mouij's instrument is in the Museum of Military Surgery at Netley.

Constitutional treatment, note 30, *p.* 484.

The pernicious influence on the British troops of the three months' residence in Bulgaria has been fully unfolded by my former colleague Professor Aitken, in a paper which will be found in vol. xl. of the *Medico-Chirurgical Transactions.* In it he has shown that the percentage of deaths in the same diseases was invariably greater, in a marked degree, during the first seven months of the Crimean war among the troops who had resided in Bulgaria, than it was among the troops who came direct to the Crimea from England or elsewhere. The same results were observed in the cases of injuries. The ratios of deaths to the total admissions for injuries were 19·1 per cent. among those men who had formed part of the force in Bulgaria; but only 13·7 per cent. among those who had served in the Crimea only. The ratios of invaliding to the admissions for injuries were 45·1 per cent. among those who had been in Bulgaria; only 20·4 per cent. among those who had served in the Crimea only. Dr. Aitken's paper is well worthy of attentive study by all medical officers who are interested in tracing the causation of disease and mortality among bodies of troops. Those who passed through the three hot and depressing months in Bulgaria during which the army was quartered in that unhealthy country, as the writer did, will not need to be reminded how important an item in the long list of agents which made that residence so constitutionally hurtful to the troops was the innutritious quality of the rations issued to the men, the unskilful manner in which they were ordinarily cooked, together with the general absence of vegetables and other necessary dietetic adjuncts. Had no other cause for deterioration of bodily health existed, the indigestible diet in Bulgaria, and the deficiency in certain classes of aliment, would alone have sufficed for bringing the health standard so low as to render the men prone to any disease that circumstances might favour, and materially to affect the mortality and invaliding results of wounds among them.

Hygiene and repair of injuries, note 31, *p.* 490.

It is never to be forgotten that the study of practical hygiene is as important for surgeons as it is for sanitary officers. The province of practical hygiene is not limited to the prevention of particular diseases; if it were, its interest would be much lessened so far as surgical injuries are concerned. It is equally its province to put men in the best state of preparation for repairing the injuries and recovering from the diseases to which they, especially soldiers, are liable to be subjected. In proportion as practical hygiene has been attended to, so will the treatment of injuries be simplified, and the death and invaliding rates be lessened; in proportion as it has been neglected, so will the difficulties of treatment be increased, and the death and invaliding rates mount higher. Army medical officers should especially keep themselves in constant familiarity with the science and practice of hygiene as taught in the invaluable works on the subject by my late distinguished colleague Dr. Parkes and his successors.

Antiscorbutics in field hospitals, note 32, *p.* 491.

During the civil war in the United States the Volunteer Aid Societies supplied enormous stores of antiscorbutic articles for the use of the wounded in the military hospitals. They consisted of dried apples, prunes, and other fruit; apple preserve, pickled tomatoes, tamarinds, lemons, oranges, lemon juice and lemonade, porter, &c. Such articles are of great value when fresh fruits and vegetables are not procurable. They are far superior, as antiscorbutics, to the dried potatoes and vegetables which are issued in large quantities in Europe, and are rarely relished, however prepared, by sick soldiers.

Treatment of secondary hæmorrhage, note 33, *p.* 501.

'Guthrie's Commentaries,' London, 1853, p. 68.

Treatment of hospital gangrene, note 34, *p.* 503.

'Military Medical and Surgical Essays, prepared for the U. S. Sanitary Commission,' edited by W. A. Hammond, M.D., Surgeon-General U. S. Army, Phil., 1864, p. 85.

Hospital gangrene in the Franco-German war, note 35, *p.* 504.

Chenu, *Guerre de* 1870–71, tome i. p. 478.

General remedies in hospital gangrene, note 36, *p.* 504.

'Lectures on Inflammation,' by J. Thomson, M.D., &c., 2nd American edition, Phil., 1831, p. 398.

Venesection in hospital gangrene, note 37, *p.* 504.

See 'Observations on Hospital Gangrene. as the Disease appeared in the British Army during the late War in the Peninsula,' by John Boggie, M.D., Surgeon to Her Majesty's Forces, Edinburgh, 1848.

Hennen's observations on venesection in hospital gangrene, note 38, *p.* 504.

'Hennen's Military Surgery,' London, 1829, p. 226.

Effects of local warmth in treatment of tetanus, note 39, *p.* 510.

Chenu, op. cit., p. 398.

Amputation in tetanus, note 40, *p.* 511.

Chenu, op. cit., pp. 405, 413.

Experience regarding tetanus in U. S. civil war, note 41, *p.* 511.

For remarks on failure of all remedies in fully developed tetanus, see Surgical History, op. cit., part iii. p. 822.

Chloroform in tetanus, note 42, *p.* 512.

Campagne d'Italie, Chenu, tome ii. p. 397.

Curare in tetanus, note 43, *p.* 512.

Allgemeine Chirurgie der Kriegswunden nach Erfahrungen in den Norditalienischen Hospitälern von 1859, von Dr. H. Demme, Würzburg, 1861, p. 146, &c.

Vapour baths in tetanus, note 44, *p.* 513.

Guerre de 1870–71, Chenu, tome i. p. 476.

Treatment of erysipelas, note 45, *p.* 517.

'On the Treatment of Erysipelatous Inflammation,' in 'Practical Obs. in Surgery, more particularly as regards the Naval and Military Service,' by A. Copland Hutchison, Surgeon, R.N., London, 1826, pp. 110–140.

Treatment of erysipelas at Metz, note 46, *p.* 518.

Chenu, *Guerre de* 1870–71, tome i. p. 472.

SECTION IX

GUNSHOT INJURIES AND FIELD SERVICE

Necessary physical qualifications of bearers, note 1, *p.* 530.

For remarks in detail on this subject see the 'Manual of Ambulance Transport,' 2nd edition, 1893, p. 83, &c.

Origin of bearer companies in the British army, note 2, *p.* 532.

Associated with me on this committee were Lieut.-Col. H. Brackenbury, R.A. (now Lieut.-Gen. Brackenbury, C.B.), and Major William Kemmis, R.A., of the Royal Carriage Department. See the report of this committee, entitled 'On the Appliances for Aid to the Sick and Wounded in War exhibited in the Brussels Exhibition of 1876;' London, printed by Eyre & Spottiswoode, for H.M.'s Stationery Office, 1876.

Establishment of a bearer company, note 3, *p.* 532.

The proceedings of the special committee referred to in the text, though printed, were confidential. The establishment of bearer companies, with tables showing the details of their constitution, was published in clause 77 of Army Circulars issued June 1, 1877.

The first bearer company actually engaged in the field was formed in 1879 during the Zulu war. It served under the general command of Colonel

H. Brackenbury, who, as previously mentioned, had studied the subject at Brussels in 1876. Surgeon-Major T. Hector, A.M.D., drilled the company, which was formed of non-commissioned officers and men of the Army Hospital Corps and African levies trained as bearers, and commanded it in the attack on Secocoeni's stronghold in South Africa. The operations of this company were attended with such success—every man who fell wounded being at once picked up and carried to the rear for surgical aid—that the Secretary of State for War called the attention of the House of Commons to them, especially to the courage of the bearers, who kept close up with the attacking troops, and to the rapidity with which all the wounded were placed under hospital treatment on the occasion.

Regimental bearers, note 4, *p.* 533.

'Journal of the Royal U. S. Institution,' vol. xx., 1876, p. 682.

Arm badge of Prussian auxiliary bearers, note 5, *p.* 534.

As these men only acted in the capacity of bearers after battles, while at other times they were engaged in ordinary military duties, it appeared to be contrary to the spirit of the Geneva Convention for them to wear the white brassard with the red cross. Numerous complaints of this misapplication of the brassard were made on the French side during the Franco-German war. These allegations led to the following ordinance by the Emperor of Germany:—

'From trusty representations made to us, we command, as a modification of § 7, of "The Instructions for the Sanitary Service of the Army in the Field, of April 29, 1869,"—that in future the auxiliary sick-bearers of the troops shall wear on the left upper arm a red band, instead of the white band with a red cross. The War Ministry will carry out the further details of this command. (Signed) WILLIAM.

'Berlin, June 6, 1872. V. ROON.'

Medical staff corps, note 6, *p.* 539.

A full account of this corps, its history, its present organisation, and the course of training undergone by the men composing it, may be found in the following works:—'A Manual of Ambulance Transport,' 2nd edition, 1893, chap. ii. sect. ii.; 'History of the Ambulance System of the British Service,' pp. 28–43. The manner in which they are instructed to perform their duties in reference to attendance on the sick and wounded in hospitals, to give first assistance to wounded men in the field, and to transport them to the field hospitals, are plainly shown in the 'Manual for the Medical Staff Corps,' War Office, 1893, Harrison & Sons, London.

Servants to medical officers, note 7, *p.* 543.

The condition of surgeons on general duty in the field has hitherto frequently contrasted unfavourably, as regards personal care and comfort, with that of the surgeons attached to regiments. The latter have had the advantage of a share of the attendance which all officers of regiments receive. They have never been in any difficulty as regards servants, so that their personal wants have been properly provided for. Not so with medical officers on general employ. Even in the autumn manœuvres in England they have been occasionally subjected to much annoyance and discomfort from want of arrangements, or at least of an adequate provision, for the

accommodation and rationing of their civil servants. Such discomfort is not likely to be experienced in future. Provision is made in the Queen's Regulations for the Army, 1894, par. 159, sect. 7, for servants to departmental officers not attached to regiments, as well as in the Allowance Regulations, 1894, par. 490. Table 40, 'Field Establishments,' shows that three servants are allotted to the three medical officers in the establishment of a bearer company.

The principal medical officer of an army, note 8, *p.* 546.

See Army Med. Regs., part i., 1890, pars. 107 and 108.

Functions of the principal medical officer, note 9, *p.* 547.

These were laid down in Part 5, sect. viii., 'Service in the Field,' pp. 117–121 of the Regs. for the Med. Dept. of H.M.'s Army, published by the War Office on the 1st of November 1878.

Field hospitals with troops on the march, note 10, *p.* 555.

All military details are of course omitted in the order of march shown in the text that are not necessary to illustrate the positions of the field hospital establishments. The details may be seen at p. 171 of 'A Précis of Modern Tactics,' by the late Major Home, R.E., London, 1873.

Flying field hospitals, note 11, *p.* 556.

The term 'flying hospital' is probably as old as the term 'flying artillery.' Dr. Monro, Physician to the Forces, has a chapter on 'Movable, or Flying Hospitals' in his work on preserving the health of soldiers, published in 1780. The same term 'flying field hospitals,' or *ambulances volantes*, has often been employed in the French military service.

Hospital ships, note 12, *p.* 566.

For a description and plan of the arrangements for accommodating patients in these ships, see vol. i. of Army Medical Reports for the year 1859, London, 1861, p. 337. See the report upon H.M.S. *Victor Emanuel*, hospital ship, with plans, by Surgeon-Major Bleckley, M.D., C.B., in Army Medical Reports, vol. xv., London, 1875, p. 260.

National Societies for aid to sick and wounded in war, note 13, *p.* 568.

An interesting account of the origin and nature of these societies, by Mr. J. Furley, may be seen in the 'Manual of Ambulance Transport,' 2nd edition, London, 1893, pp. 56–77, chap. iii., 'On the Convention of Geneva and its Badge, the Red Cross.'

Egyptian expedition of 1882, *note* 14, *p.* 570.

For a full account of this expedition, see the report by the principal medical officer of the force, in the vol. of Army Medical Reports for 1881, App. No. 1, p. 204, &c.

Arrangements on a force quitting England, note 15, *p.* 581.

For the manner in which inspections of transports are to be conducted, and the particular subjects of inquiry, see the Queen's Regulations and

Orders for the Army, edition 1894, sect. 17, 'Movement of Troops by Sea,' pars. 39–44. For further instructions, see Army Medical Regulations, 1894, p. 11, pars. 59–61, and p. 30, sect. 1, pars. 182–188.

Field hospital organisation, note 16, *p.* 590.

'Millingen's Army Medical Officer's Manual,' London, 1819, p. 241. It will be seen, by reference to this admirable work, that nearly all the principal improvements which have been introduced of late years into the field medical arrangements of European armies are advocated in it, as the results of his experience during the Peninsular wars.

Field panniers, note 17, *p.* 599.

The result of the experience of the war in the north of China in 1860 led Sir Wm. Muir, the principal medical officer of the expeditionary army, to report them to be 'the most useful and portable ever furnished to an army' (Army Medical Department Reports, vol. ii., London, 1862, p. 378). Sir Anthony Home, V.C., in his report of the Ashanti campaign, calls them 'the invaluable, the nearly perfect field panniers' (A. M. Dep. Reports for 1873, vol. xv. p. 249).

Reserve field panniers, note 18, *p.* 607.

Army Medical Regulations, 1894, sect. 2, pars. 545, 546.

Field hospital equipment, note 19, *p.* 619.

'Autobiography of Sir J. M'Grigor, Bart.,' p. 94.

Field hospital pharmacy waggons, note 20, *p.* 623.

See 'Report of the Field Hospital Equipment Committee, with Summary of Proceedings, together with Drawings of Pharmacy Waggon Mark I., Mode of Packing, &c.,' London, printed for H.M.'s Stationery Office, 1877. The contents of this pharmacy waggon, *when ordered for service*, with plans of the interior arrangements, appeared as Appendix No. 46 in the Regulations for Medical Services, part i., 1890, but are omitted in the corresponding Regulations of 1894.

Hospital tents and marquees, note 21, *p.* 624.

'Report of the Royal Commissioners,' p. 48. Consult also on this subject, Army Medical Regulations, 1894, p. 80, par. 509.

Field bedsteads, note 22, *p.* 625.

'Instructions to Regimental Surgeons for Regulating the Concerns of the Sick,' Appendix No. 11, London, 1808.

Substitutes for ambulance stores, note 23, *p.* 627.

Larrey, *Mémoires de Chir. Mil., &c., Campagne de Russie*, vol. iv. p. 31.

Readiness of resource in war, note 24, *p.* 627.

'Life of Dr. Jackson,' London, 1845, p. 34.

Want of special instruments, note 25, *p.* 627.

Campagne d'Italie de 1859 : Lettres Medico-Chir. par le Dr. A. Bertherand, Méd. Prin. de 1ère Classe, Paris, 1860, p. 163.

Stretchers, note 26, *p.* 629.

The name *stretcher* is comparatively a modern one. At the time of the Peninsular wars the English name of these hand-litters was not stretchers, but *bearers*. They then had no traverses to keep the poles apart and stretch the canvas, but merely consisted of a loose piece of canvas with looped edges, through which the poles were passed. The French give the name of *brancard* to this conveyance, from its side poles, *les branches*.

Carriage of stretchers, note 27, *p.* 633.

Army Medical Reports for year 1866, vol. viii., London, 1868, p. 613.

Ambulance transport by mule carriage, note 28, *p.* 652.

For other particulars concerning mule cacolets and mule litters, and directions concerning their use, I may refer to the 'Treatise on the Transport of Sick and Wounded Troops,' previously quoted. See also the very instructive and interesting 'Report on the Transport of Sick and Wounded by Pack Animals,' by G. A. Otis, U. S. Army, Washington, 1877. This report embodies the experience of many campaigns in which the U. S. troops have been engaged with Indians in regions inaccessible to wheeled vehicles.

Sick-transport waggons, note 29, *p.* 652.

In the 'Treatise on Transport of Sick and Wounded Troops,' before mentioned, means are described for breaking the severity of the shocks which unsuitable ambulance vehicles are liable to inflict on wounded men, and also various contrivances for converting country springless waggons into suitable ambulance conveyances.

Construction of ambulance waggons, note 30, *p.* 659.

Many points of interest connected with the construction and purposes of the ambulance sick-transport waggon, now distinguished as the Mark IV. waggon, will be found in the 'Report of the Committee appointed by Sir John Pakington, Secretary of State for War, on April 24, 1868, to inquire into the general question of Hospital Conveyances for the Army.'

Austrian railway sanitary trains, note 31, *p.* 666.

See on this subject *Studien über den Umbau und die Einrichtung von Guterwaggons zu Sanitäts-waggons,* mit 9 Tafeln, Wien, 1875. The late Dr. Billroth's excellent work, *Ueber den Transport der Verwundeten und Kranken auf Eisenbahnen im Felde,* Gerold, Wien, 1874, may be consulted on the subject of railway ambulances with advantage.

Railway ambulance transport in general, note 32, *p.* 666.

Experimental trials of various means of carrying wounded soldiers, not described in the text, have been made from time to time on the Continent. They are mostly noted in a special chapter on the subject in the second edition of the 'Treatise on Ambulance Transport,' previously mentioned.

SECTION X

CLASSIFICATION OF GUNSHOT INJURIES

Denomination of gunshot injuries, note 1, *p.* 667.

Also *scloppus.* Persius, in his 5th Satire, censuring a pompous style of declamation, writes, 'Nec scloppo tumidas intendis rumpere buccas.' See Delphin edition, London, 1786, p. 363. The word appears to have been sometimes written *stloppus* or *stlopus.*

Some foreign designations of gunshot wounds, note 2, *p.* 668.

The other equivalent terms for *gunshot wound* given in the nomenclature are—*blessure par arme à feu,* French; *schusswunde,* German; and *Palla di schioppo,* Italian. The Italian words *schioppo,* a gun; *schioppetto,* a musket; and *schioppettiere,* a fusilier, are simply modifications of the Latin *scloppus,* mentioned in the previous note.

Returns of casualties after actions, note 3, *p.* 671.

'As soon as possible after an action, medical officers in charge of field hospitals will furnish nominal rolls, in duplicate, on Army Form A 6, of officers, warrant-officers, non-commissioned officers, and men who have received wounds or injuries in battle, specifying as tersely and accurately as possible the kind of wound or injury, and the degree of severity' (Army Medical Regulations, 1894, 'Special Returns in the Field,' sect. 2, par. 610, p. 95). Medical officers attached to regiments in the field are no longer required to furnish similar returns. See Army Medical Regulations, 1894, par. 196.

Taylor's classification, note 4, *p.* 672.

Mr. Taylor published his classification, together with some explanatory observations, early in the year 1856, under the title of 'A Classification of Wounds and Injuries received in Action, proposed for use in Military Hospitals, submitted to the Director-General of the Army and Ordnance Medical Departments, and to the Principal Medical Officer with the Army in the Crimea,' by J. R. Taylor, C.B., Deputy-Inspector-General, camp near Sebastopol, January 26, 1856.

Wounds of invalids from the Indian Sepoy war, note 5, *p.* 673.

The 'Descriptive Numerical Returns of Wounds and Injuries received in Action during the Mutiny in India, &c.,' up to June 30, 1859, are published in 'Notes on the Wounded from the Mutiny in India,' by G. Williamson, M.D., Staff-Surgeon, London, Churchill, 1859, pp. 5 and 115. These returns are completed up to December 31, 1862, at p. 463 of the 4th vol. of the Army Med. Dept. Reports, in the year 1862, London, 1864.

Classified list of wounds in New Zealand war, note 6, *p.* 673.

'The New Zealand War of 1863–65, &c.,' by Inspector-General Mouat, V.C., C.B., vol. vii., Army Med. Dept. Reports for 1865, Lond., 1867, p. 473.

Special classifications compared, note 7, *p.* 683.

See vol. liv. of the Transactions published by the Royal Med. and Chir. Soc. of London in 1871. The chief object of this paper was to estimate the relative merits of the different plans which had been adopted for framing the official returns of injuries inflicted in battle, from which the general tables showing the total surgical results of certain wars had been subsequently formed; and also to try and excite an interest in the subject of the adoption of a common system for collecting such information in all regular armies. There appeared to me to be some practical objections to the forms of returns which had been originally issued for collecting the statistics of injuries in the field during the United States civil war, and I thought it might be useful to mention them. These objections excited the displeasure of Dr. Otis, the able compiler of the surgical history of the war. This feeling he expressed in some remarks in the Introduction (p. 26) to the first part of the history, and in other ways that I prefer not to refer to now. I have already replied to his remarks above mentioned, in a short paper published in the *American Journal of the Medical Sciences* for October 1873. Although Dr. Otis did me, as I felt at the time, some wrong, I have always been ready to express my admiration of the great talents and industry which he has displayed in bringing together and co-ordinating in his Surgical History of the War of the Rebellion the vast amount of information furnished by the many very expert surgeons engaged in the hospital practice of the U. S. armies, as well as in his able comments upon the results of their labours.

SECTION XI

STATISTICS OF GUNSHOT INJURIES

Hits to shots fired in sieges, note 1, *p.* 688.

'History of the Siege of Gibraltar, 1779–83,' by J. Drinkwater, Captain 72nd Regt.; London, J. Murray, 1844. See in the Appendix to this work, 'General Return of Casualties,' and 'Return of Expenditure of Ammunition.'

In various bombardments, note 2, *p.* 688.

Les Forteresses Françaises pendant la Guerre de 1870–71, par J. Prevost, Lt.-Col. de Génie à Vincennes, J. Dumaine, Paris.

Ratios of hits to special missiles, note 3, *p.* 691.

'Surgical History of Crimean War,' vol. ii. p. 264.

Ratios of hits by small and large missiles, note 4, *p.* 691.

Chenu, *Armée d'Orient*, Paris, 1865.

Hits to missiles, Franco-German war, note 5, *p.* 693.

The numbers given by Fischer are: officers and men killed by rifle-shot, 6969; by shell splinters, 695; or, in round numbers, 10 to 1 killed by rifle-

shot; wounded by rifle-shot, 49,093; by shell, 4389.—*Statistik der verluste in dem Kriege* 1870–71, *im Preussischen Heere, &c.*, von G. Fischer, Berlin, 1876, p. 6.

Lists of casualties after battles, note 6, *p.* 694.

M. Boudin mentions that the official report respecting the assault of Constantine in Algeria, on October 13, 1837, gave a total of 506 wounded, of whom 38 were officers, among a force of 12,453 combatants; but on the following day, the 14th, the number of wounded on the hospital returns was only 309, of whom 27 were officers. The difference in the stated numbers on the two successive days was probably due to the injuries of some being so slight as not to require hospital treatment, so that they at once rejoined the ranks for duty.—*Système des Ambulances des Armées Françaises et Anglaises*, p. 7, Paris, 1855.

Losses from sickness attributed to wounds, note 7, *p.* 695.

So persistent is the impression that the proceeding named in the text is still practised, that, even with regard to so comparatively recent an action as the battle of the Alma, the following statement was made in a work published by a gentleman holding an official position in a military office, where he had special facilities for acquiring information on such subjects: 'The French casualties were reported as about 1400 *hors de combat;* these are believed to include all those who died in the Dobrudscha' ('Medals of the British Army, &c.,' dedicated by permission to the Hon. Sir J. Y. Scarlett, K.C.B., Adjutant-General, &c., by T. Carter, London, 1861, p. 20), that is, men who had died from disease two months before the battle, and when the French army had not even landed in the Crimea. Statistics, however, are too carefully scrutinised nowadays for such a falsification as this to be practised without speedy detection. We have sufficient proof that the total French loss at the Alma closely approached the number at first stated. Dr. Chenu's returns, founded on the names of the officers and soldiers concerned, show that the French casualties at the Alma were 141 killed, 1197 wounded, and 3 unaccounted for; total, 1341. The losses of the French in the Dobrudscha are separately given by Dr. Chenu, and he shows that they were far greater than is supposed in the quotation above given, or than they were generally believed to be at the time they occurred. The number of officers and men attacked by cholera in that fatal expedition was 3138, and of them 2277 died. Altogether, in July 1854, in which month the Dobrudscha expedition started on its fatal errand, there were 8239 cases of cholera in the French army in the East, and 5039 men, or one-eleventh of its total strength at the time, succumbed to the scourge in that month. The plain, unvarnished narrative by Dr. Chenu of the sudden visitation and effects of the cholera, by which the advance of the troops under Generals Espinasse and Jusuf was arrested in the Dobrudscha, is one of the most moving episodes in his great work on the medical and surgical history of the French army of the East.

Decrease of losses in war, note 8, *p.* 697.

'Military Gymnastics of the French,' by A. Steinmetz, Lieut. Queen's Own Light Infantry Militia, &c.—*Journal of the United Service Institution*, vol. v. p. 385.

Effects of changes in arms on losses, note 9, *p.* 697.

'Memorandum on the Prussian Army in relation to the Campaign of 1866,' by Colonel Reilly, R.H.A.

Authorities for statements in text, note 10, *p.* 699.

The following historians were consulted in respect to the strength of the French, Prussian, Russian, Austrian, and British armies, and their casualties in the earlier battles named in the table: Schloezer, Meyer, Rotteck, Becker, Luder, Soltyk, Roeder, Pelet, Gourgand, Ségur, Buturlin, Larrey, Alison, Creasy, Coxe, and others. The calculations respecting the more recent battles are based on information obtained from official sources.

Losses at battle of Austerlitz, note 11, *p.* 700.

A large number of Russian and Austrian troops, who were forced into the lakes in rear of the position of the allies during the battle, and drowned, are included in the 26,200 casualties. M. Thiers estimates the French loss in killed and wounded at 4500 only.

At battle of Maida, note 12, *p.* 700.

Major-General Sir J. Stuart's returns.

At battle of Talavera, note 13, *p.* 700.

'The Despatches of F.-M. the Duke of Wellington during his various Campaigns,' vol. iii. p. 375. 'Napier's Peninsular War,' London, 1839, vol. ii. p. 406.

At battle of Albuera, note 14, *p.* 700.

Official returns, quoted in 'Medals of the British Army,' by T. Carter, formerly of the Adjutant-General's Office, Horse Guards, London, 1861, 2nd edition, p. 91. In the first returns 580 were shown as 'missing;' but as 'nearly all reported as missing subsequently rejoined their regiments,' they are omitted in the calculations in the table.

At the siege of Badajos, note 15, *p.* 700.

Strength of the troops employed at the siege, from Napier, op. cit., vol. iv. p. 585. Numbers killed and wounded from Carter, op. cit., p. 107. Napier, op. cit., vol. iv. p. 588, gives the loss as killed 875, wounded 3787, missing 62. Probably an earlier return.

At the assault of Badajos, note 16, *p.* 700.

Napier, op. cit., vol. iv. p. 587.

At battle of Salamanca, note 17, *p.* 700.

Napier, op. cit., vol. v. pp. 620–621. The numbers of strength and losses are exclusive of officers, sergeants, trumpeters, artillerymen, and staff. In Napier's 'History of the Peninsular War,' the strength shown is almost always the strength of effective sabres and bayonets.

At battle of Bautzen, note 18, *p.* 700.

These numbers include those of the losses on the 19th, 20th, and 21st May 1813.

At battle of Vittoria, note 19, *p.* 700.

Napier, op. cit., vol. v. p. 622.

At battle of Leipzig, note 20, *p.* 701.

Some accounts give the strength of the allies at Leipzig as 240,000, and place the casualties, especially among the French, at a much higher figure.

At battle of Toulouse, note 21, *p.* 701.

Napier, op. cit., vol. vi. p. 707. Strength, all ranks: Anglo-Portuguese cavalry and infantry under arms, 37,917; Spaniards, 14,000; artillerymen, 1500; total, 53,417. But Napier says (p. 671) only 24,000 men really fought the battle. For the total loss, see Napier, vol. vi. p. 649, and Carter, op. cit., p. 148. Accepting the statement that only 24,000 were engaged, the percentage of killed would be 2·47, of wounded 16·85, and total loss 19·33.

Losses at battle of Waterloo, note 22, *p.* 701.

The strength of the British troops, taken from the 'Morning State' of the British army on the morning of the battle of Waterloo, 18th June 1815. Actually present at the battle: officers, 1894; sergeants and troop quartermasters, 2061; trumpeters or drummers, 700; rank and file, 31,585; total, 36,240. See 'Selections from the Wellington Despatches,' Gurwood, London, 1851, p. 862. Numbers of killed, wounded, and missing among the British and Hanoverian troops, op. cit., p. 861. The greater number of the men returned 'missing' had gone to the rear with wounded officers and soldiers, and rejoined afterwards. The strength of the Hanoverians and the German Legion, and the losses of the latter, are from Siborne.

At battle of the Alma, note 23, *p.* 701.

British strength, inclusive of officers, sergeants, drummers, rank and file. More than half the number killed, and nearly half the number wounded, occurred in the four regiments of the light division which assaulted the Russian hill-battery. See 'Kinglake,' vol. ii. p. 506. French and Russians, Chenu, *Armée d'Orient*, Paris, 1865, pp. 42–44. The 1008 Russians missing were probably wounded prisoners. This would alter the ratio of killed to wounded to 1 to 2·1.

At battle of Inkerman, note 24, *p.* 701.

English, official returns; French and Russians, Chenu, *Armée d'Orient*, pp. 60, 63.

Losses during the whole Crimean war, note 25, *p.* 701.

British—the strength given comprehends the total number of officers, non-commissioned officers, and privates sent out to the Crimea during the war. For numbers of killed and wounded, see the 'Official Surgical History of the Crimean War,' vol. ii. p. 259 and p. 380. French, officers and troops, Chenu, p. 574.

At battle of Montebello, note 26, *p.* 701.

The figures in this and the following Italian battles include officers, non-commissioned officers, and rank and file, as is customary in Continental

army enumerations. They are taken from French official statements. The strength of the French army on the 4th June (Magenta) was 127,453; of the allied French and Sardinian armies on the 24th June (Solferino) was 187,956 combatants; the figures in the table show only the strength of the troops said to have been actually engaged.

During whole Italian war of 1859, *note* 27, *p.* 701.

French—total effective combatants engaged in action during the war, Chenu, *Guerre d'Italie*, tome ii. p. 851. All ranks are included in the killed, wounded, and missing, op. cit., p. 853. The missing include prisoners.

At battle of Shiloh, U.S., note 28, *p.* 701.

The number of the Union and Confederate losses in this and the following American battles is extracted from the 'Chronological Summary of Engagements and Battles' in the 'Medical and Surgical History of the War of the Rebellion,' part i. vol. ii., Washington, 1870. Six principal battles at various periods of the war have been selected for illustration. Shiloh, op. cit., pp. 44.

At battle of Antietam, note 29, *p.* 701.

Op. cit., p. 58. Strength of all arms present for duty, and casualties, reported by General M'Clellan. Medical Director Letterman's returns show 8350 wounded, but he says 'many cases of slight wounds are not recorded.' The numbers given of the strength and losses of Confederates under General Lee were estimated by General M'Clellan. The quartermaster-general reported having buried 2700 Confederates left dead on the field of battle. The estimates of General Lee's fighting strength are probably exaggerated, but the losses not over-estimated.

At battle of Murfreesboro', note 30, *p.* 701.

Op. cit., p. 66.

At battle of Gettysburg, note 31, *p.* 701.

Op. cit., p. 80. Strength taken from the morning report of General Meade's aggregate force of July 1st, 1863. In this number large bodies of troops guarding trains, protecting lines of communication, &c., are understood to have been included. The Confederate strength is assumed, as General Lee is known to have had that number present for duty in June 1863. The stated loss includes 13,621 men reported on the muster-roll of the provost-marshal of the army of the Potomac as prisoners. The 13,621 missing are believed to have been killed or wounded.

Losses at battle of Chickamauga, note 32, *p.* 701.

Op. cit., p. 87. General Rosencrans states he had 'less than 50,000 men in line of battle.' The adjutant-general of the army reported General Rosencrans' aggregate at this battle as 5570 officers and 88,706 men; total, 94,276. But this is believed to include all the troops in the immense 'department of the Cumberland.' A very large number of the wounded of General Rosencrans' army were left on the field; these doubtless form part

of the 4945 reported as 'missing.' The Confederate strength is the number of General Bragg's army after being reinforced by General Longstreet's corps. The Confederate 'missing' were prisoners.

At the battle of Wilderness, note 33, *p.* 701.

Op. cit., p. 106. Union strength approximate.

Losses, all United States civil war, four years, note 34, *p.* 701.

'Medical and Surgical History of the War of the Rebellion,' part i. vol. ii., Introduction, p. 26. The aggregate missing of the Confederates includes the armies surrendered.

Loss in New Zealand war, note 35, *p.* 701.

Strength given is the average strength of the troops employed throughout the war. See Army Medical Reports, vol. vii., 1867, pp. 400 and 411. See also Appendix, p. 311, to 'The Maori War in New Zealand,' by Major-General Sir J. E. Alexander, London, 1873.

In Prusso-Danish war, note 36, *p.* 702.

From General-Arzt. Dr. Löffler's Returns. (*a*) The number of killed on the battle-field. The strength given is the *average total strength* of the Prussian contingent. The greatest strength was 63,500. (*b*) Proportion of strength actually engaged. See report of General-Arzt. Löffler. (*c*) The number of wounded among the Danes mentioned in Dr. Löffler's report is probably the number admitted into the Prussian field hospitals, the slightly wounded having made their escape. This will explain the large proportion of killed to wounded among the Danes.

At battle of Königgrätz, note 37, *p.* 702.

(*a*) Prussians.—In the first line the full fighting strength of the Prussians, combatants of all ranks, is given. (*b*) But of the fighting strength about 80,000 infantry and 12,000 cavalry never came into action: this number is deducted in the second line, the strength of troops engaged being given alone. (*c*) Austrians and Saxons.—The Austrian official accounts give as the strength—infantry (Austrian and Saxon together), 174,902; cavalry, 23,798; artillery, 16,328; total, 215,028: this number is taken as the strength in the first line. (*d*) But as 65,000 were reported as not having been engaged, the strength reduced by this number is taken in line (*d*).

Colonel Cooke, R.E., who has given a summary of the campaign in Austria of 1866, including a description of the battle of Königgrätz, in the Professional Papers of the Corps of Royal Engineers (vol. xv., 1866, p. 174), has remarked: 'The losses in this battle were very small, considering the number of men engaged and the duration of the fighting.' No doubt they were so if the total numbers on each side are regarded as all having been engaged in the conflict, and this is probably the only way in which the subject would be regarded by combatant officers. But, regarded surgically, that is, considering the number of the wounded to be professionally attended to and cared for, the losses in this battle were very large. And practically we know that the losses were so very large that the necessary attention could not possibly be given to them, and that many—no one can say how many—lives were lost in consequence. What with the fact that

the Prussians marched on their way to Vienna on the day but one after that on which the battle was fought, taking with them a large proportion of the surgical staff, the 7000 wounded Prussians and the enormous number of wounded Austrians and Saxons, who remained in the hands of the victors lying scattered over an extensive area, together formed a multitude out of all proportion to the limited surgical staff and attendants who were available for rendering the help required of them. Days elapsed before the needed assistance could be brought from other places—unhappily only after the numbers wanting it had been very considerably lessened by death. Colonel Cooke states the total engaged in the battle as 415,000, and the number killed and wounded as 28,000. He thus shows the proportion of killed and wounded to have been $\frac{1}{15}$th of the numbers engaged. The action lasted from about 8 A.M. to about 4 P.M.

Losses in chief battles of Franco-German war, note 38, *p.* 702.

The strength, numerical losses in killed, wounded, and missing among the Germans in this and the succeeding battles of the Franco-German war, are taken from *Die Verluste der Deutschen Armeen*, von Dr. Engel, Berlin, 1872. The strength and numerical losses of French troops in the principal battles of the war are given on the authority of Médecin-Principal Dr. Morache, and are copied from the article by him, entitled *Soldat*, in the *Dictionnaire Encyclopédique des Sciences Médicales*, 3rd series, vol. x. p. 235.

German loss in whole Franco-German war, note 39, *p.* 702.

The strength given by Engel of the troops in the different battles is their *normal* strength; but as the *losses* in killed, wounded, and missing were probably replaced from time to time by fresh troops, corresponding numbers might well be added. If this were done, as is done in the British strength given for the Crimean war, where every individual sent to recruit the strength is included, then the percentage of the losses would be proportionally diminished, and the ratio of killed to wounded also changed. The 17,570 shown as killed were killed on the battle-field, or died within twenty-four hours after being wounded. As there were still 4009 missing at the conclusion of the war, they may be fairly included among the dead, but whether from wounds or disease cannot be determined.

The ratio of killed to wounded, according to Fischer, who limits his statistics to the armies of Prussia and the North German contingents, is nearly the same as is shown in the table for all the Germans. His figures are—killed, 13,556; wounded, 75,321; total killed and wounded, 88,877. These give 15·2 per cent. killed and 84·8 per cent. wounded, or about 1 killed to 5·6 wounded.

Target area of the human body, note 40, *p.* 704.

'Tables of the Skeleton and Muscles of the Human Body, by B. S. Albinus;' translated from the Latin, &c.; London, 1749; elephant folio. Tab. i., External Muscles of the Body, Full Front. Tab. ix., The same, Side View. See also Andrew Bell's edition of Albinus, dated Edinburgh, February the 17th, 1777.

Regional areas in ancient statues, note 41, *p.* 706.

Estimated from plates in 'The Proportions of the Human Body measured from the most Beautiful Antique Statues,' by Mons. Andran, &c.; in 27 large folio plates; London, C. Bowles, 1770.

Wounds of the hand in war, note 42, *p.* 709.

The number of gunshot wounds of the hand and fingers examined on this occasion was nearly three thousand (2632). Some unscrupulous persons, wishing to lessen in the eyes of Napoleon the number of wounds caused in the battles of Lützen, Bautzen, and Würtzen, had ascribed many of them to self-mutilation. After examining each wounded man individually, the board of which Larrey was president declared that the charge made against these wounded soldiers was false. Although the Emperor was at first irritated with Larrey at the decision, after reading the papers he was so convinced of its justice, and of the courage with which Larrey had repelled the accusation against the troops concerned, that he sent him his portrait enriched with diamonds. See *Campagnes du Baron D. J. Larrey* (*Campagne de Russie*), tome iv., Paris, 1817. p. 170; and for a fuller account of the transaction, *Le Baron Larrey*, par le Général Baron Ambert, Paris, 1863, p. 50.

Gunshot wounds, by regions, in war, note 43, *p.* 714.

History of U. S. War, op. cit., Surg. vol., part iii. chap. xii. p. 693.

Number wounded and percentage of death, note 44, *p.* 717.

Das Preussische Militair-Sanitätswesen und seine Reform, Löffler, Berlin, 1868, part ii. p. 24.

Wounds fatal in the field in New Zealand, note 45, *p.* 719.

Army Medical Reports, vol. vii. p. 473.

Fatal wounds in action in United States civil war, note 46, *p.* 720.

See the Surg. Hist. of the War, op. cit., part iii., Surg. vol., chap. xii. p. 692.

Directly fatal wounds in Danish war, 1864, *note* 47, *p.* 720.

General Bericht über den Gesundheitsdienst im Feldzuge gegen Dänemark, 1864, Löffler, Berlin, 1867, p. 46.

Regional fatality of wounds in Crimea (*French*), *note* 48, *p.* 721.

Chenu, *Campagne d'Italie*, tome ii. p. 849. (Wounds and amputations the situations of which are undetermined are omitted.)

Fatality of abdominal wounds, note 49, *p.* 722.

Wounds of the abdomen by bullets, large projectiles, and fragments of shell. Wounds of the inguinal region are counted with those of the abdomen. Herniæ and injuries resulting from different causes than projectiles are excluded.

Of wounds of the extremities, note 50, *p.* 722.

The numbers under wounds of upper and lower extremities include the cases in which amputations or other surgical operations were performed. Wounds of the scapula and clavicle are included under upper extremities in Dr. Chenu's classification; in some others they are classified with wounds of the chest.

Regional fatality of wounds in Crimea (British), note 51, *p.* 722.

See 'Surgical History of Crimean War,' vol. ii. p. 259 and p. 380. A slight discrepancy is shown in the percentages of mortality of wounds of the extremities in the table and in the surgical history of the war. This is owing to wounds of joints being shown separately in the table in the text.

Regional fatality in last New Zealand war, note 52, *p.* 722.

Calculated from the classified returns in Army Medical Reports, vol. vii. p. 474–77.

Regional fatality after battle of Waterloo, note 53, *p.* 723.

Note on an interleaved copy of Sir C. Bell's 'Dissertation on Gunshot Wounds,' in the Bell collection at Netley. (See Army Medical Reports, vol. vii. p. 596, London, 1867.

Regional fatality in Prusso-Danish war, note 54, *p.* 723.

Löffler, op. cit., p. 46. Dr. Löffler's history of the Prusso-Danish war is not complete as regards details of wounds of the lower extremities. The numbers under joints, blood-vessels, and nerves, refer only to those of the upper extremity (Löffler, p. 137); the corresponding anatomical structures of the lower extremities are included in the numbers wounded under 'lower extremities.'

Regional fatality in war of 1866, *note* 55, *p.* 724.

Wounds of the scapula and clavicle are included by Stromeyer under the heading of upper extremities in this table. This will probably have increased the ratio of mortality.

Mean regional fatality of gunshot wounds, note 56, *p.* 726.

Corrected mean, obtained by multiplying each ratio by its combination weight, *i.e.*, the square root of the total number of cases, then summing up the ratios thus treated, and dividing by the sum of the square roots of the total numbers of cases in each group.

Regional fatality in United States civil war, note 57, *p.* 726.

'Surg. Hist. of War of Rebellion,' part iii. chap. xii. p. 691, table 119.

Progressive results of gunshot wounds, note 58, *p.* 727.

The figures in the two tables on p. 612, showing the progressive mortality and dates of recovery of wounded men under hospital treatment, are taken from the General Return C., Crimean History, vol. ii., History of Disease, sect. xiii. p. 246. See also vol. ii. p. 388.

Wounds of nerves, &c., in table B., note 59, *p.* 729.

The numbers of the wounds of nerves, vessels, and joints absent in this line are included in the numbers of regional wounds shown elsewhere in the column.

Slight and severe wounds in French army, note 60, *p.* 730.

The numbers in the table regarding the Italian campaign are from the general table at p. 849, tome ii., of Chenu's *Armée d'Italie;* those of the Crimean war, from the separate tables in Chenu's *Armée d'Orient.* No general table is given in Chenu's Crimean History, similar to that in the history of the Italian war, nor are the numbers in the columns of 'Pensionnés' in the former divided into 'Retraités' and 'Pensionnés temporairement,' as they are at p. 849, above quoted, of the second volume of the latter work.

Accidental gunshot wounds in action, note 61, *p.* 732.

Army Medical Reports for 1865, vol. vii. p. 479.

Other accidental injuries in campaigns, note 62, *p.* 733.

'Surgical History of Crimean War,' vol. ii. p. 380.

Ultimate results of wounds, note 63, *p.* 735.

These two tables, showing the final results of all the wounds among British troops treated in the hospitals during the Crimean campaign, have been formed from information contained in different parts of the Official Surgical History of the War (see pp. 257–59, pp. 388 et seq.).

THE GENEVA CONVENTION OF 1864

(*See p.* 579.)

The Articles in which the terms of this Convention are embodied are nine in number, and the following is a copy of them translated into English. The original articles were in French, and were presented in that language when the accession of the British Government to the treaty was laid before Parliament.

'Articles of the Convention, signed at Geneva, August 22nd, 1864, for the Amelioration of the Condition of the Wounded in Armies in the Field, and acceded to by the British Government on the 18th February 1863.

Article I.

'Ambulances and military hospitals shall be acknowledged to be neuter, and, as such, shall be protected and respected by belligerents so long as any sick or wounded may be therein.

'Such neutrality shall cease if the ambulances or hospitals should be held by military force.

Article II.

'Persons employed in hospitals and ambulances, comprising the staff for superintendence, medical service, administration, transport of wounded, as well as chaplains, shall participate in the benefit of neutrality whilst so employed, and so long as there remain any wounded to bring in or to succour.

Article III.

'The persons designated in the preceding article may, even after occupation by the enemy, continue to fulfil their duties in the hospital or ambulance which they serve, or may withdraw in order to rejoin the corps to which they belong.

'Under such circumstances, when those persons shall cease from their functions, they shall be delivered by the occupying army to the outposts of the enemy.

Article IV.

'As the equipment of military hospitals remains subject to the laws of war, persons attached to such hospitals cannot, in withdrawing, carry away any articles but such as are their private property.

'Under the same circumstances an ambulance shall, on the contrary, retain its equipment.

Article V.

'Inhabitants of the country who may bring help to the wounded shall be respected and shall remain free. The generals of the belligerent powers shall make it their care to inform the inhabitants of the appeal addressed to their humanity, and of the neutrality which will be the consequence of it.

'Any wounded man entertained and taken care of in a house shall be considered as a protection thereto. Any inhabitant who shall have entertained wounded men in his house shall be exempted from the quartering of troops, as well as from a part of the contributions of war which may be imposed.

Article VI.

'Wounded or sick soldiers shall be entertained and taken care of, to whatever nation they may belong.

'Commanders-in-chief shall have the power to deliver immediately, to the outposts of the enemy, soldiers who have been wounded in an engagement, when circumstances permit this to be done, and with the consent of both parties.

'Those who are recognised, after they are healed, as incapable of serving, shall be sent back to their country.

'The others may also be sent back on condition of not again bearing arms during the continuance of the war.

'Evacuations, together with the persons under whose directions they take place, shall be protected by an absolute neutrality.

Article VII.

'A distinctive and uniform flag shall be adopted for hospitals, ambulances, and evacuations. It must on every occasion be accompanied by the national flag. An arm badge (*brassard*) shall also be allowed for the individuals neutralised, but the delivery thereof shall be left to military authority.

'The flag and arm badge shall bear a red cross on a white ground.

Article VIII.

'The details of execution of the present Convention shall be regulated by the commanders-in-chief of belligerent armies, according to the instructions of their respective Governments, and in conformity with the general principles laid down in this Convention.

Article IX.

'The high contracting powers have agreed to communicate the present Convention to those Governments which have not found it convenient to send plenipotentiaries to the International Conference at Geneva, with an invitation to accede thereto; the protocol is for that purpose left open.'

Additional articles, some particularly designed for extending the provisions of the foregoing Convention to men wounded in naval warfare, have been proposed and approved at subsequent conferences in Geneva, Brussels, and Paris. As, however, these proposed additions have never been ratified by the respective powers who are parties to the Geneva Convention of 1864, and therefore have no official weight in warfare, they are not here quoted.

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